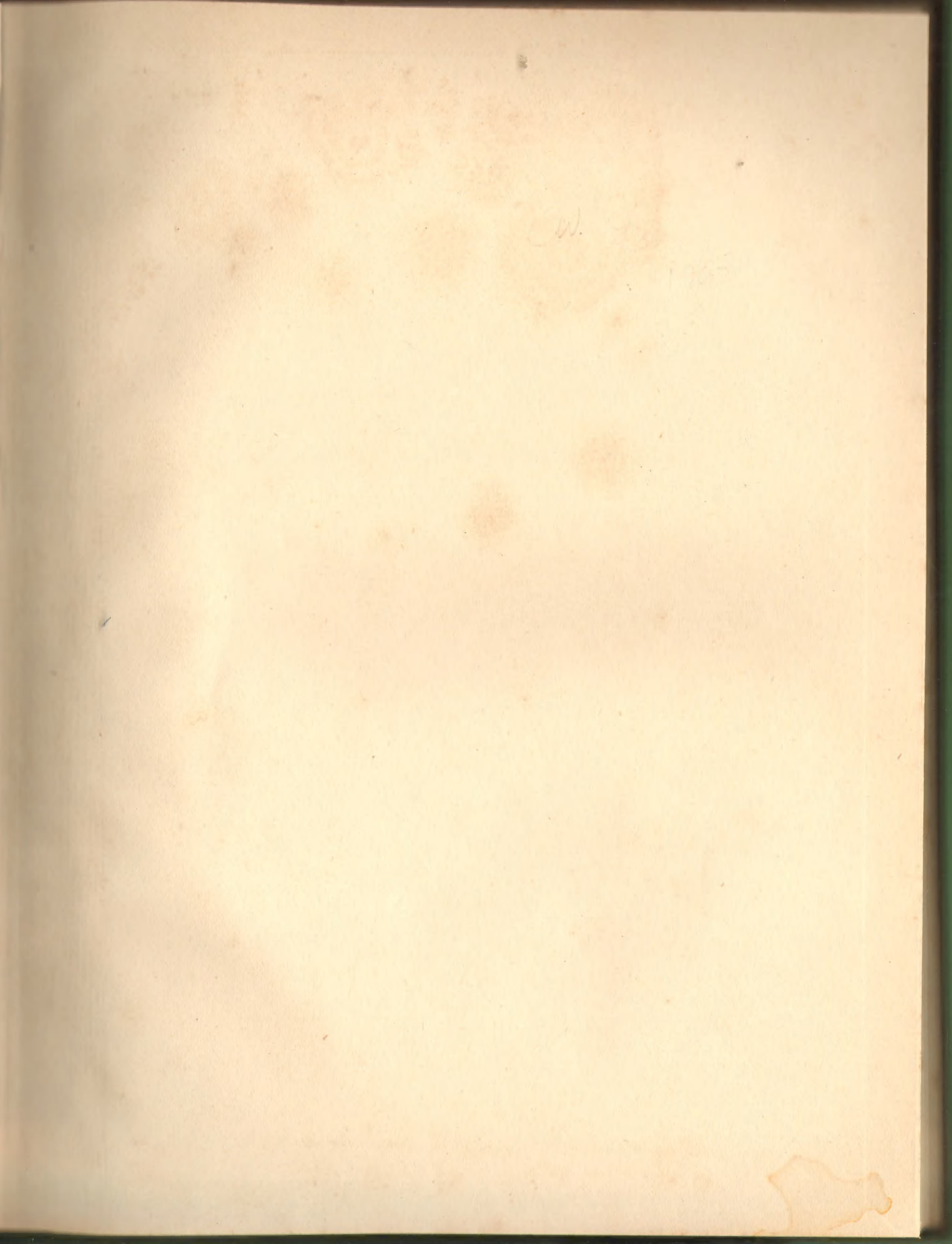


MALAYAN
LOWER
CARBON-
IFEROUS
FOSSILS

MUIR-WOOD

HEIR-MUR
(NAT. HIST.)
1903



MALAYAN
LOWER CARBONIFEROUS FOSSILS
(AND THEIR BEARING ON
THE VISEAN PALAEOGEOGRAPHY OF ASIA)

BRITISH MUSEUM
(NATURAL HISTORY)

MALAYAN LOWER CARBONIFEROUS FOSSILS

AND THEIR BEARING ON
THE VISEAN PALAEOGEOGRAPHY OF ASIA

BY
HELEN MARGARET MUIR-WOOD

With contributions by
W. N. EDWARDS, K. P. OAKLEY, STANLEY SMITH, and
C. J. STUBBLEFIELD

WITH SEVENTEEN PLATES AND THREE FIGURES IN THE TEXT

LONDON :
PRINTED BY ORDER OF
THE TRUSTEES OF THE BRITISH MUSEUM

Issued June, 1948]

[Price One pound ten shillings]

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KINGSWAY, LONDON, W.C.2

MADE AND PRINTED IN GREAT BRITAIN
BY JARROLD AND SONS LTD., NORWICH

PREFACE

LATE in 1939 Mr. E. S. Willbourn, Director of the Geological Survey of the Federated Malay States, sent a large suite of Upper Palaeozoic fossils from Pahang to the Geological Department of the British Museum (Natural History) for examination. The collection proving to be of very considerable interest, it was subsequently agreed to publish an account of it in the Journal of the Malayan Branch of the Royal Asiatic Society. The majority of the specimens were brachiopods, and the brunt of the work of investigation fell on Dr. H. M. Muir-Wood, who carried out most of the necessary research during 1940 and 1941 while on night duty at the Natural History Museum, to the accompaniment of falling bombs and anti-aircraft gunfire. The co-operation of Dr. C. J. Stubblefield (Geological Survey and Museum) was secured in the study of the trilobites and of Dr. Stanley Smith (Bristol University) of the corals. My colleague, Dr. K. P. Oakley, dealt with the bryozoans, molluscs and crinoids, and I examined some fragmentary plant remains. Plates were printed in England for publication in the Asiatic Society's journal and copies of the completed typescript were despatched to Mr. Willbourn by different routes in the autumn of 1941.

Then came the Japanese war. The typescript was not delivered (fortunately, perhaps, since all three copies eventually reached the British Museum again) and Mr. Willbourn was interned. Through the kind offices of Mr. J. B. Scrivenor (formerly Director of the Geological Survey of the Malay States) the Colonial Office assumed responsibility for the cost of the plates, which for greater safety were stored at Mr. Scrivenor's house in Bedford until the end of hostilities. After Mr. Willbourn's return to England in 1945 the Trustees of the British Museum undertook to publish the monograph, since it was no longer possible to carry out the original plan.

Mr. J. B. Scrivenor has added to our indebtedness by reading the whole of the typescript and offering many valuable criticisms and suggestions, while in the final revision we have fortunately been able to consult Mr. E. S. Willbourn and his colleague Mr. F. H. Fitch. The palaeogeographical review has been made as complete as possible, though under present conditions it is almost inevitable that some important works have been overlooked. In particular, we have been unable to consult all the relevant papers published in recent years in the U.S.S.R. We must, therefore, apologize to our Soviet colleagues for any omissions that there may be in their particular field.

W. N. EDWARDS,
Keeper of Geology.

August 1946.

CONTENTS

	PAGE
I. INTRODUCTION	I
II. PREVIOUS PALAEOZOIC FOSSIL RECORD OF MALAYA (Pl. XVI).	I
III. LIST OF THE FOSSIL LOCALITIES IN PAHANG (Fig. 1)	6
IV. LIST OF SPECIES OBTAINED	8
V. CORRELATION AND AGE OF MALAYAN FAUNAS	9
VI. PALAEOGEOGRAPHY OF VISEAN OF ASIA (Pl. XVII)	19, 108
VII. SYSTEMATIC DESCRIPTIONS OF BRACHIOPODA (Pls. I-X)	24
(1) Lower Carboniferous of Bukit Charas, Bukit Sagu, and Bukit Tinggik	24
(2) Lower Carboniferous of Sungei Terapai	57
VIII. REFERENCES	68
IX. APPENDIX. LEPIDODENDROID REMAINS FROM MALAYA. <i>By</i> W. N. Edwards (Pl. X)	78
X. APPENDIX. LOWER CARBONIFEROUS FOSSILS FROM MALAYA: BRYOZOA, MOLLUSCA AND CRINOIDEA. <i>By</i> Kenneth P. Oakley (Pls. XI, XII)	82
XI. APPENDIX. CARBONIFEROUS CORALS FROM MALAYA. <i>By</i> Stanley Smith (Pl. XV)	93
XII. APPENDIX. CARBONIFEROUS TRILOBITES FROM MALAYA <i>By</i> C. J. Stubblefield (Pls. XIII, XIV)	97
XIII. EXPLANATION OF PLATES	103
INDEX	111

I. INTRODUCTION

THE Lower Carboniferous fossils here described were obtained by Messrs. E. S. Willbourn, F. H. Fitch, and rock-collectors of the Federated Malay States Geological Survey, from the Kuantan district of Pahang, eastern Malaya. These specimens are mentioned by E. S. Willbourn in 1940 (p. 27), while the locality Bukit Charas is referred to by Scrivenor in 1920, 1922 and 1926. A brief reference to the Kuantan [Sungei Terapai] trilobites, which are said to be probably of Culm age, is made by Scrivenor in 1941 (p. 129).

The Brachiopoda, which predominate, are of importance as the first identifiable Lower Carboniferous specimens so far collected in Malaya. Appendices on the other fossil groups have been contributed by W. N. Edwards (Plants), K. P. Oakley (Mollusca and Bryozoa), Stanley Smith (Corals), and C. J. Stubblefield (Trilobites).

The types and the greater part of the collection have been presented to the British Museum (Natural History) by the courtesy of Mr. E. S. Willbourn, to whom we are indebted for the opportunity of studying the material. Duplicate specimens will be preserved in the Geological Survey collections at Batu Gajah, Malaya. Thanks are due to Mr. F. H. Fitch for his field-notes on the Pahang localities. The map showing Malayan fossil localities (pl. XVI) has been adapted from that published in *The Geology of Malaya* (1931) by kind permission of Mr. J. B. Scrivenor and Messrs. Macmillan & Co.

II. PREVIOUS PALAEOZOIC FOSSIL RECORD OF MALAYA

(Pl. XVI)

The stratigraphical succession in Malaya is still imperfectly known owing to the scarcity of fossils, to the metamorphism of the sediments, to the immense amount of folding and faulting, and to the dense vegetation obscuring the outcrops. Rastall (1927) gave the succession in the Kinta Valley of Perak as:

- (1) Recent Alluvium.
- (2) High Level Alluvium. Gopeng Beds.
- (3) Western Boulder Clays.
- (4) Intrusion of Mesozoic Granite.
- (5) Schist series and Tekka Clays. (Triassic).
- (6) Limestone (Carboniferous or Permo-Carb.).

Scrivenor, in his general account of Malayan geology (1931), gives the succession in the legend to his geological map as:

Recent	Coast Deposits and Alluvium
	Rhyolitic volcanic ash (Kuala Plus Perak)
Miocene or later	Tertiary bedded rocks
	Dolerite younger than Granite
Mesozoic	Vein Quartz
post-Trias	Granite porphyry
	Granite and allied very acid rocks
	Hornblende Granite
	Syenite
	Diorite (Upper Perak)
Trias (and Permian?) . .	Quartzite and Shales
Between Trias and Carboniferous	Chert and associated Shales
Unknown	Serpentine Gabbro
Carboniferous to Trias . .	Pahang Volcanic Series
	Quartz-porphyry older than the Granite
	Limestone and Calcareous Shales and other Raub Series rocks
Carboniferous (and Permian?)	Limestone Hills
	Quartzite and Shale below Limestone, e.g. Langkawi's

Lower Carboniferous sediments are the oldest fossil-bearing rocks so far found in Malaya. Scrivenor (1941) mentioned the occurrence of possible Devonian and Silurian in Dutch New Guinea, and Devonian in the islands of Celebes and Borneo, but stated that these records had not been definitely confirmed.

The distribution of Palaeozoic beds in the East Indies is, however, reviewed by Umbgrove (1938), and by Smit Sibinga (1940). Loose limestone blocks containing the coral *Halysites* identified by Teichert (1928) as *H. wallichi* Reed are probably of Silurian age, but Silurian beds have not been found in situ in the Archipelago. Similarly, fossiliferous blocks of sandstone and grauwacke with *Heliolites porosus* and brachiopods of Devonian age are said to occur along the River Lorentz, and at other localities in New Guinea, but nowhere else in the East Indies. No marine Lower Carboniferous is recorded,

but marine Stephanian is indicated in Umbgrove's sketch-map in eastern and central Malaya, and in Sumatra. These Malayan deposits are now found to be Viséan. Marine Carboniferous or Permian are also shown in eastern and western Borneo, in Celebes, western New Guinea, Sumatra, and western Malaya.

In Malaya, the Carboniferous and Permian are best exposed in the Langkawi Islands, off the west coast of the peninsula in coast sections described by Scrivenor (1920, p. 3), and by Scrivenor and Willbourn in 1923 (p. 338). The beds consist of two divisions: (1) lower beds, about 5,000 ft. of quartzites and shales with an occasional thin, impure limestone band; (2) upper beds, about 5,000 ft. of limestone with obscure crinoid remains, a flat gastropod and bryozoa recorded by Scrivenor and Willbourn (1923, p. 341) as Carboniferous, but considered by Newton (1926a, p. 62) to be probably Uralian or Permian in age; and 700 ft. of interbedded shale and quartzite. Above these conformably come hardened shales and quartzites without fossils, but the conglomerates characteristic of the Upper Trias of the mainland are not represented. This upper series of conglomerates, sandstones, grits, and shales was described by Scrivenor as the Tembeling series in 1907. Later he renamed them Malayan Gondwanas, but in 1931 he referred to these rocks simply as Triassic. On the mainland at Goa Laman Maling, Perlis, close to the south-west frontier of Siam, fossils were found in a calcareous quartzite belonging to the lower sedimentary series of Langkawi Islands with a north to south strike and vertical dip. These fossils, described by Newton (1926a, p. 49, 1926b, p. 4) as of Upper Carboniferous or Permo-Carboniferous (=Uralian) age, were identified as *Fusulina* cf. *granum-avenae* (also found in Sumatra), *Doliolina* cf. *lepida*, *Myriopora*?, *Chaetetes* sp., *Stenopora* sp., *Cyathocrinus*?, *Fenestella* cf. *retiformis*, *Schizodus* sp., *Pleurophorus* sp., and a cyathophylloid coral. A white limestone was said to overlie these beds conformably. A silicified limestone or chert near Bukit Chuping, Perlis, contained large fusulinids near to *Fusulinella konnoi* Ozawa of Upper Carboniferous or Uralian age (Scrivenor, 1922, p. 5, 1926, p. 180); while at Bukit Taming,¹ at the southern end of Bukit Tungku Lambu Range, Perlis, Willbourn (1926, p. 308) stated that quartzites with no intercalated shales pass up conformably into limestone, containing brachiopods and a *Euomphalus* of doubtful age. Crinoid remains and indeterminate fossils were recorded by Scrivenor and Jones (1919) from limestone at Changkat Pari, near Ipoh, Perak, west of the Main Range. In the Kinta district of Perak the lower series appears to be absent, and limestones containing crinoid stems form the bedrock of the tin-mines. These limestones tend to form rugged hills disposed along north-north-east to south-south-west lines, and comparable with those of Pahang. Limestones die out in Malaya towards the south which was evidently the direction of the Tethyan coastline.

On the eastern side of the peninsula in Pahang there are extensive outcrops of calcareous or argillaceous shales or slates, as well as of limestone, which is often crystalline and occurs as large lenticular masses in the shale. Calcareous shale forms the country rock of the Raub Gold Mines, and the name Raub Series was formerly applied by Scrivenor (1907) to these rocks of Carboniferous and ?Permian and Trias age. Lavas and volcanic tuffs, known as the Pahang Volcanic Series, are often interbedded with the Raub Series, and are thought to have been chiefly submarine eruptions which began in the Carboniferous and continued into the Trias.

Cherts which occur as sheets or lenticular bodies are sometimes interbedded with the Pahang Volcanic Series, and closely associated with the Raub Series and Trias in Pahang. These cherts which may contain indeterminate radiolaria, bryozoa, sponge-spicules, and

¹ The fossils from this locality preserved in the British Museum (Nat. Hist.) consist of a bellerophonitid and other gastropods, and fragmentary specimens of brachiopods identified as a rhynchonellid and an orthotetid, possibly a species of *Orthotetina*, which are thought to be of Permian age.

foraminifera, were at first thought to be deep-water deposits comparable with those of the Culm (Scrivenor, 1907, p. 7), and accumulated while calcareous rock was deposited elsewhere. Owing to their frequent association with quartzites, they are now considered to be shallow water, possibly lagoon deposits, a supposition supported by the finding of drifted plant remains in chert pebbles in the Tekai River, tributary of Sungei Tembeling, Pahang (Scrivenor, 1931, p. 78). Cherts containing radiolaria occur in south Kedah, Perak, in the Kinta district, and Selangor in the west of Malaya, and in Kelantan, Trengganu, and Pahang in the east, and are often interbedded with quartzites. Examination of the radiolaria of the Singapore cherts by Hinde (Scrivenor, 1907, and 1926) showed that they gave no clue to the age of the rock, and also that they were not related to the radiolaria of the cherts of Borneo, which are of Triassic and Jurassic age. The frequent occurrence of pebbles of chert in the Upper Triassic conglomerates shows that some at least of the cherts must be older than Upper Trias. Scrivenor (1931, p. 76) states that the bulk of the cherts occur immediately above the Carboniferous Series and at the base of the quartzites and shales of the Trias, and that they may be of Trias age or older.

Fragmentary fossils were recorded from the shale of Sungei Lembing by Scrivenor (1922),¹ and imperfect fossils and crinoidal remains were described by Newton (1901, p. 189) in limestone from the hill Goa Sah, and in marls at Goa Bama, in the old Punjom Concession, Pahang. At Lubok Sukum between Kuala Kechau and Kuala Chika, Pahang, casts and impressions of fossils were identified from shales with harder sandstone bands by Crick and Newton (in Scrivenor, 1907, p. 4, and Scrivenor, 1911a, p. 34) as *Xenodiscus* and *Dentalium* cf. *herculea*. Both these fossils occur in the Upper Productus Limestone of the Salt Range, and a Permian age was consequently suggested by Newton and Crick. Examination of the matrix of these specimens showed it to be reddish-brown iron-stained shaly limestone, banded and only a few inches thick.

Carboniferous fossils found by Scrivenor (1905, p. 1) in a light grey crystalline limestone at Mill Gully and Goa Sah on the old Punjom Concession near Kuala Lipis, Pahang, were identified by Crick (in Scrivenor, 1911a, p. 34) as *Orthoceras*, *Cyrtoceras*, *Gyroceras*, and *Solenocheilus*. Later, Newton (1913, p. 370) stated that these fossils and an imperfect coral found at the same locality were of Lower Carboniferous, Visean age. Visean corals characteristic of the *Dibunophyllum* zone were also recorded by Dr. S. Smith in 1920 and 1926 from Bukit Charas, Kuantan, Pahang; the determinations are revised in Part XI of this paper. A brachiopod collected by Mr. Willbourn from the same locality was determined by Mr. Scrivenor as *Strophomena* sp. (Scrivenor, 1926, p. 181), but this identification is incorrect.

More recently crinoid remains, and one doubtful coral, obtained from the limestone bedrock at Foo Bros.' Hydraulic Gold Mine near Sungei Temau railway-halt, Pahang, were examined by Mr. L. Bairstow, but the fossils unfortunately gave no indication of the age of the rock (Bairstow in Willbourn, 1938, pp. 7, 30).

In addition to these marine fossils, plant remains obtained from shale interbedded with ash from the mouth of Sungei Chiku, a tributary of the Galas, Kelantan, north-east Malaya, were identified by Edwards (1926, p. 171) as *Pecopteris* cf. *cyathea* and *Cordaitea* sp. of Stephanian age, and comparable with the plant beds of Sumatra described by

¹ The Pahang Consolidated Company report that about the year 1935, while clearing the overburden on their tin-mining concession of Sungei Lembing, they found crinoid stem ossicles, small brachiopods, and obscure plant remains, in shales at a point about 1½ miles south of the junction of Sungei Kenau and the Sungei Kuantan. Later, in 1938, a member of their staff found several brachiopods, one moderately well preserved (which from the oral description given of it may have been a *Leptaena*) in indurated shale in the roof of a stope at the Sungei Lembing tin mine, about half a mile south-west of the first site. It has not been possible to examine this material, and it is not known, therefore, whether these shale specimens from Sungei Lembing are comparable with the Sungei Terapai fauna and plant remains.

Jongmans and Gothan (1925) and Zwierzycki (1935). There is, however, no trace of the *Glossopteris* flora which occurs in Peninsular India and Australia.

From the above evidence we find that Lower Carboniferous (Viséan) corals, molluscs and brachiopods occur in limestone at Bukit Charas, Pahang, and corals and cephalopods in limestone at Mill Gully, near Kuala Lipis, Pahang, eastern Malaya.

Uralian [Lower Permian] fusulinids, corals, bryozoa, crinoids, and molluscs have been described in a calcareous quartzite, and fusulinids from a silicified limestone from the Perlis district of Kedah; crinoid remains, gastropods and bryozoa in limestone from the upper sedimentary division of the Langkawi Islands, western Malaya.

Upper Permian¹ cephalopods and scaphopods occur in shales with harder sandstone bands at Lubok Sukum, Pahang.

Fossils of either Carboniferous or Permian age have been recorded from limestones of Kinta, Perak, from near Sungei Temau and Goa Sah, Pahang (crinoid remains); from cherts of Singapore, Kedah, and Pahang, etc. (radiolaria, foraminifera, and bryozoa); from limestone overlying quartzite of Bukit Taming, Perlis (brachiopods and gastropods); from shales of Sungei Lembing, Pahang (indeterminate fossils). Fossiliferous outcrops also occur on the Pahang River and on the Tanum River.

Plants of Stephanian age have been described from shale interbedded with ash in Kelantan, north-east Malaya, while chert pebbles in Pahang have yielded plant remains of indeterminate age.

Tournaisian, Moscovian, and marine Upper Carboniferous are at present unknown in Malaya.

Lower Trias is at present unknown, but marine fossils of Middle and Upper Trias have been described by Newton (1900, 1905, 1906, 1923, 1925), T. R. Jones (1905), Weir (1925), and Cox (1936) from various localities from a series of shales, quartzites and conglomerates. Fossil wood of Triassic age has been described by Edwards (1933).

Jurassic (? Bajocian) marine fossils and plant remains were described by Newton (1906) from Mount Guthrie, Singapore, but were considered by Scrivenor (1931, p. 107) to be Triassic.

Neogene (? Upper Miocene) freshwater shales with *Viviparus* have been described from a boring at Durian Chandong, Kepong, Johore (Cox, 1937).

¹ A small collection of specimens from Sungei Jemeru, south-west of Bukit Jemeru, Kuala Lipis, Pahang, recently sent to the British Museum (Nat. Hist.) by Mr. Willbourn, has been identified as *Leptodus* [*Lyttonia*] cf. *tenuis* Waagen, *Marginifera* sp., *Dictyoclostus* sp., *Uncinunellina timorensis* (Beyrich) and an alate spiriferid. A separate note on these Upper Permian forms will be published in the future.

III. LIST OF FOSSIL LOCALITIES

Figs. 1 & 3¹

The fossils, consisting mainly of brachiopods, with only a few poorly preserved molluscs, one coral, trilobites, bryozoa, crinoid, and plant remains were obtained from four localities, all in Kuantan, Pahang, eastern Malaya.

- (1) Bukit Charas, from north side of hill. [Locality Nos. 5048 and 9904 of F.M.S. Geol. Surv.]
- (2) Bukit Tinggik² from two outcrops close together on east side of hill. [Locality No. 14896.]
- (3) Bukit Sagu, from foot of hill at south-west corner. [Locality No. 14895.]
- (4) Sungei Terapai, stream section. [Locality No. 14897.]

LOCALITIES 1-3 are in north-east Pahang on the eastern side of the peninsula and consist of limestone hills, situated on an approximately north-to-south line, about seven miles long. These hills rise steeply from flat ground to a height of several hundreds of feet, and form a striking topographical feature. Bukit Charas, the most southerly of the three hills, is about fifteen miles west-north-west of Kuantan, and half a mile north of the village of Panching on the narrow-gauge railway of the Pahang Consolidated Co. Ltd. Bukit Sagu is five miles north, and Bukit Tinggik seven miles north-east, of Bukit Charas. All three hills are composed of limestone which has been much thermally metamorphosed by granite, or altered by earth movements. The fossils in consequence are usually poorly preserved, and veins of calcite cut across many of the specimens. A fourth limestone hill, Bukit Panching, lies half a mile slightly west of south of Panching, but no fossils have been collected from this locality. Red unfossiliferous shales were observed between Bukit Sagu and Bukit Tinggik, but their relation to the limestone is obscure, and outcrops are rare owing to the abundant vegetation. The fossils from all three localities are preserved in a similar light grey massive limestone from which it is difficult to extract entire specimens. This limestone is slightly darker in colour and less crystalline than that occurring at Mill Gully and Goa, Pahang, from which were obtained the specimens of *Orthoceras*, *Cyrtoceras* and *Solenocheilus*, identified by Crick in 1911 (in Scrivenor, 1911a) and 1926.

LOCALITY 4. Sungei Terapai is one of the tributaries of the Sungei Kuantan, the river which drains the Pahang Consolidated Company's Tin Mining Concession in east Pahang, and is north-west of Sungei Lembing, where the principal tin-mine is situated. The specimens were obtained from a band of shale about 1 ft. thick, between two bands of quartzite. The quartzite jutted out from the west bank half-way across the stream, but the shale had weathered back to the bank and fossil collecting was consequently extremely difficult without resort to blasting. Marine fossils, brachiopods, trilobites, one lamelli-branch, and crinoid ossicles often preserved as impressions or internal casts, were found about two and a half miles upstream from the junction of the Sungei Terapai and Sungei Kuantan. Indeterminate fossil plants were obtained from a cliff on the east side of the Sungei Terapai from a similar shale band of approximately the same age about half a mile downstream from the marine fossil locality. This series of interbedded shales and quartzites, with shales predominating, previously mapped as Trias for want of definite fossil evidence, outcropped along the river between the two fossil localities with an average dip to the east-north-east varying from 10° to 40°.

¹ The sketch-map reproduced as fig. 1 was prepared during war-time from inadequate data, and is supplemented by fig. 3 (see p. 110) which is taken from the 1-inch topographical survey map.

² On the Pahang Consolidated Company's Concession map this name appears as Bukit Tenggek. This spelling has been used in the sketch-maps, figs. 1 and 3.

The majority of the country in the Pahang Consolidated Company's Concession consists of sediments, largely shales and sandstone, which have undergone differing amounts of thermal metamorphism by granite, and dynamic metamorphism caused by earth movements. Biotite granite occurs south of the shale localities and extends to Sungei Lembing. It is this granite which is responsible for the tin mineralization. Granite also occurs to the north near the Pahang-Trengganu boundary. Pebbles of both granite and thermally metamorphosed sediments occur on the banks of the Sungei Terapai at the marine fossil

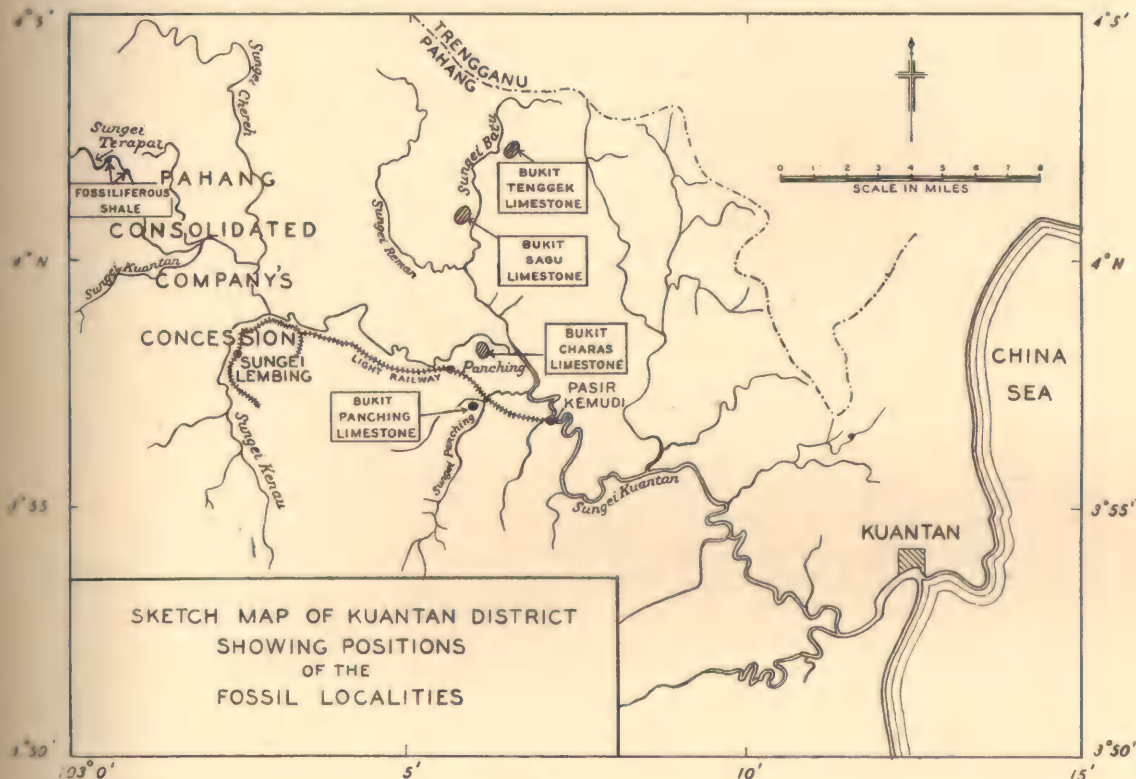


FIG. 1.

locality, which is situated midway between these two granite masses, but the fossiliferous rocks show no sign of thermal metamorphism (see footnote, p. 4).

The weathered rock from which the fossils were collected consists of a light-coloured, white or pale grey arenaceous shale, lacking in calcium carbonate, and frequently stained brown or yellowish with iron oxide, or grey with carbonaceous material. It is usually soft and friable and rather chalky in texture; before weathering it was a black graphitic shale.

Microscope slides have been examined by Dr. J. Phemister of the Geological Survey, London, who has given the following report on the rock in its weathered condition: "The rock is an argillaceous siltstone composed mainly of finely divided micaceous material and an isotropic substance. The latter is probably some hydrated aluminous or magnesian silicate. Quartz grains are numerous in this base and minor constituents are flakes of detrital muscovite and biotite, some few prisms of tourmaline and a considerable number of small grains of decayed rock. I see nothing particularly ashy in it, but fine volcanic material may have contributed to it."

IV. LIST OF SPECIES OBTAINED FROM PAHANG

I. BUKIT CHARAS

- ANTHOZOA.** *Caninia* near *C. gigantea* Michelin, *C. sp.*, *Lithostrotion* {*Diphyphyllum*} *sp.*, *Amygdalophyllum* *sp.*
BRACHIOPODA. *Avonia weberi*† (Yanishevsky), *Dictyoclostus* *sp.**, *Krotovia multituberculata*† (Yanishevsky), *Linoproductus kokdscharensis*†* (Gröber), *Linoproductus tenuistriatus*†* (de Vern.), *Brachythyris willbourni** *sp. nov.*, smooth Spiriferid*†, *Spirifer* *sp. (striatus group)**, *Athyrid*††.
MOLLUSCA. *Pterinopectinella cf. granosa* (J. de C. Sow.).

II. BUKIT TINGGIK

- ANTHOZOA.** *Amygdalophyllum* *sp.*
CRINOIDEA. "*Poteriocrinus*" *sp.*
BRACHIOPODA. *Schizophoria mesoloba* (Yan.), *Stenosisma saguensis* *sp. nov.*, *Chonetes* *sp.†*, *Buxtonia* *sp.*, *Dictyoclostus* *sp. muricatus* group†, *D. cf. deruptus* (Romanowsky), *D. sp.*, *Eomarginifera* *sp.†*, *Echinoconchus* *sp.*, *Gigantella cf. latissima* (Sow.), *Krotovia cf. keyserlingiana* (de Kon.), *Sinuatella orientalis* *sp. nov.*, *Marginicinctus?* *cf. planus* (Yan.), *Pugnax asiaticus* *sp. nov.*, *P. cf. pugnus* (Martin), *Brachythyris willbourni* *sp. nov.*, *B. koksensis* Dik., *cf. Choristites? humerosus* (Phill.), *Neospirifer derjawini* (Yan.), *Spirifer scriivenori* *sp. nov.*, *S. sp.†*, *Phricodothyris* *sp.*, *Reticularia imbricata* (J. Sow.), *Athyrid*†.
MOLLUSCA. *Edmondia* *sp.*, *Streblopteria* *sp.*, ?*Streblochondria* *sp.*

III. BUKIT SAGU

- CRINOIDEA.** "*Poteriocrinus*" *sp.*
BRACHIOPODA. *Schizophoria mesoloba* (Yan.), *Schizophoria* *sp.*, *Stenosisma saguensis* *sp. nov.*, *Avonia cf. davidsoni* (Jarosz), *Avonia weberi* (Yan.), *Buxtonia* *sp.*, *Dictyoclostus* *sp.*, *Krotovia multituberculata* (Yan.), *Linoproductus kokdscharensis* (Gröber), *Linoproductus yunnanensis* (Loczy), *Proboscidella nana* *sp. nov.*, *Sinuatella orientalis* *sp. nov.*, *Brachythyris koksensis* Dikareva, *Brachythyris willbourni* *sp. nov.*, *Brachythyris?* *buckmani* Yan., *Brachythyris* *sp.†*, *Neospirifer derjawini* (Yan.), *Spirifer cf. condor* d'Orb., *Spirifer scriivenori* *sp. nov.*, *Phricodothyris* *sp.*, *Reticularia cf. alexandri* George, *Reticularia imbricata* (J. Sow.), *Cleiothyridina* *sp.*, *Dielasma cf. attenuatum* (Martin), *Dielasma* *sp.*
MOLLUSCA. *Streblopteria* *sp.*, ?*Solemya* *sp.*, *Orthonychia* *sp.*, ?"*Dentalium*" *sp.*

IV. SUNGEI TERAPAI

- PLANTAE.** *Lepidodendron* *sp.*, *Stigmara* *sp.*
CRINOIDEA. "*Poteriocrinus*" *sp.*
BRACHIOPODA. *Schizophoria* *sp.*, *Leptaena cf. analoga* (Phill.), *Chonetes* *sp.*, *Dictyoclostus cf. parvus* (Meek & Worthen), *Echinoconchus elegans* (M'Coy), *Productina cf. margaritacea* (Phill.), *Hustedia cf. radialis* (Phill.), *Punctospirifer pahangensis* *sp. nov.*
BRYOZOA. *Fistulipora* *sp.*, *Fenestella cf. angustata* (Fischer v. Waldheim), *Fenestella cf. tenax* Ulrich, *Fenestella cf. polyporata* (Phillips), *Fenestella aff. plebeia* M'Coy, *Cystodictya* *sp.*
MOLLUSCA. *Anthraconeilo aff. taffiana* Girty.
TRILOBITA. *Linguaphillipsia terapaiensis* gen. et *sp. nov.* C. J. Stubblefield, "*Phillipsia*" *sp.*

* = Loc. 5048. † = Loc. 9904. ‡ = not described owing to poor state of preservation.

V. CORRELATION AND AGE OF MALAYAN FAUNAS

No information regarding the age of the Malayan limestone and shale faunas can be obtained from the stratigraphical succession since faulting, folding, metamorphism, and an extensive cover of soil and alluvium have rendered this quite obscure. Nor do there appear to be any glacial beds of Upper Carboniferous or Permian age comparable with those of India and Australia. The boulder clays of western Malaya, thought by Scrivenor (1911b, p. 11, 1913, p. 353 and 1931, p. 71) to be glacial deposits older than the granite, were regarded by Rastall (1927) as later than the Mesozoic granite, but the whole question is very complicated. No traces, however, of a Palaeozoic glaciation have been found in the adjoining East Indies islands.

The fossils have, therefore, to be relied on entirely for establishing the age of the beds. Foraminifera and cephalopoda do not occur, and brachiopoda predominate in both faunas.

A.—AGE OF LIMESTONE AT BUKIT CHARAS, BUKIT SAGU, AND BUKIT TINGGIK

Only one coral was obtained from Bukit Tinggik, and this was examined by Dr. Stanley Smith, together with specimens previously collected from Bukit Charas. A brief note on the Bukit Charas material has been published by Dr. Smith in 1920, and the results of his re-examination of the material appear in Part XI of this volume. The Bukit Tinggik specimen is identified by him as *Amygdalophyllum*¹ sp. and its affinities are with *A. etheridgei* Dun and Benson from the Visean, Lower Kuttung Beds, of Babbinsboon, New South Wales, and *A. inopinatum* (Etheridge jun.) from the Lower Carboniferous of New South Wales, and of Lion Creek, Stanwell, Queensland. In 1934 Hill states that the rich coral fauna of Lion Creek and Riverleigh, Queensland, is deduced to be Upper Visean, or possibly a higher horizon. The Australian fauna is found to be distinct from that of Asia and the European Dinantian. The difference is thought to be due to age or province, since the facies—reef coral and bedded limestone—is similar. The Bukit Charas material, which includes two specimens of *Amygdalophyllum* and other species comparable with British forms, also appears to be of Visean age.

Gastropods and lamellibranchs are sparsely represented in the limestone and the specimens are imperfectly preserved. Identifications of some of these forms are given by Dr. K. P. Oakley (pt. X), but it has not been possible to correlate them with species of adjacent regions.

Twenty-five species or varieties of brachiopoda have been identified from Bukit Sagu, twenty-four from Bukit Tinggik, and only nine from Bukit Charas. Of these, *Brachythyris willbourni* sp. nov. occurs in all three localities, but only one fragment was found at Bukit Charas. *Linoproductus kokdscharensis* occurs at Bukit Charas and doubtfully at

¹ The distribution of the genus *Amygdalophyllum* is discussed by Dr. D. Hill in Geol. Mag. LXXIV, 1937, p. 146. The species referred by her to this genus are, in addition to the two from the Lower Carboniferous of New South Wales, *A. thomsoni* (de Kon.) from the Lower Carboniferous of Jervis Bay and Colocolo, New South Wales; *A. nantanense* Huang from the Uralian of North Kwangsi, China; *A. wangi* Chu from the Middle Carboniferous of Yunnan, and *A. quiringi* Weissmehl from the Moscovian of North Spain. *Echigophyllum* from the Omi-mura Limestone of Echigo, and possibly also from the province of Nagato, Japan, is said to be a synonym of *Amygdalophyllum*, confirmed by Hayasaka in 1939. Hill also suggests that the genus *Koninckophyllum* from the Lower Carboniferous of Europe, Asia, and North America, as well as other Middle and Upper Carboniferous genera, may equal *Amygdalophyllum*. The range of *Amygdalophyllum* appears to be from Visean up to Permian. The exact horizon of the limestone bearing the specimens of *Echigophyllum* at Omi-mura, Japan, is uncertain, as Tournaisian as well as Visean forms were found at the same locality as this coral.

Bukit Sagu. *Avonia weberi* (Yan.) and *Krotovia multituberculata* (Yan.) occur at Bukit Charas and Bukit Sagu.

Ten species are common to Bukit Sagu and Bukit Tinggik—*Schizophoria mesoloba* (Yan.), *Stenosisma saguensis* sp. nov., *Buxtonia* sp., *Dictyoclostus* sp., *Sinuatella orientalis* sp. nov., *Brachythyris willbourni* sp. nov., *Neospirifer derjawini* (Yan.), *Spirifer scrivenori* sp. nov., *Reticularia imbricata* (J. Sow.) and *Phricodothyris* sp.

It can be assumed, therefore, that beds of similar age occur at all three localities, and that the limestone of Bukit Sagu is equivalent to that of Bukit Tinggik. At Bukit Charas, however, the limestone is less fossiliferous than at the other two localities and may include slightly lower beds. Many of the specimens bear a marked resemblance to western European forms, and especially to those of Great Britain and Belgium, although this resemblance is sometimes superficial. *Reticularia imbricata* (J. Sow.) in Malaya is represented by specimens which are indistinguishable from British forms, while the following have been compared with British or western European species: *Avonia* cf. *davidsi* (Jarosz), *Gigantella* cf. *latissima* (J. Sow.), *Krotovia* cf. *keyserlingiana* (de Kon.), *Pugnax* cf. *pugnus* (Martin), *Reticularia* cf. *alexandri* (George), cf. *Choristites*? *humerosus* (Phill.), *Dielasma* cf. *attenuatum* (Martin). These species are all Visean forms, though some of them, such as *Reticularia imbricata*, and *Pugnax pugnus*, range from C₂-D₂. The remainder, however, are characteristic of the *Dibunophyllum* zone. This similarity of so many Malayan forms to western European species seems to indicate some close connection between European and eastern Asiatic seas in Visean times.

In comparing the Malayan species with those of adjoining regions very few similar forms can be found.

AUSTRALIA.—Little is at present known about the Visean brachiopods of Australia where Lower Carboniferous occurs in New South Wales and Queensland. The Burindi Beds of New South Wales, formerly thought to be Visean by Benson (1924), David (1924), and others, are proved to be Tournaisian by Schuchert (1929) and Carey (1937), and the brachiopoda described by Benson (1921), Dun (1900), and Dun and Benson (1920) are not comparable with the Malayan limestone species. The overlying Lower Kuttung Beds contain a marine horizon with the coral *Amygdalophyllum etheridgei* Dun & Benson from Babbinboon, New South Wales, formerly incorrectly identified as a *Zaphrentis*, and thought to be from the Burindi Beds. It is now established as a Lower Kuttung, Visean species to which the Malayan species of *Amygdalophyllum* is related. The Lower Kuttung brachiopods have been listed in Carey (1937) as *Productus*? *semireticulatus*, *Spirifer* cf. *mosquensis*, *S. duplicicost[at]us*, *Spiriferina*?, *Camarophoria*?, *Reticularia lineata*. Until these forms have been adequately described and figured no comparison can be made with the Malayan species.

EAST INDIES.—No fossiliferous Visean limestones occur in the East Indies. In Timor and adjacent islands no Lower Carboniferous has yet been recorded, although fossiliferous Permian beds are well developed and are also found in New Guinea. In Sumatra, Lower Carboniferous beds were described at Sungi Landak, in Djambi, west Sumatra, by Meyer (1922) and Tobler (1907), but the specimens, including a large *Leptaena*, are not comparable. Other so-called Lower Carboniferous deposits of Sumatra have been shown by Volz (1904) and Brouwer (1924, 1925) to be of Permian age. The specimens described and figured by H. Woodward (1879) from a black limestone at Siebel above Pandang, Sumatra, are not comparable with the Malayan forms. This Sumatra collection, preserved in the British Museum (Nat. Hist.), consists of three productids, *Dictyoclostus* sp., *Cancrinella* sp., and *Marginifera* sp., and a smooth spiriferid. These specimens are probably of Upper Carboniferous or Lower Permian age.

In Borneo, beds of Carboniferous or Permian age consist of sediments with much

chert, and a volcanic series comparable with that of Sumatra, and with the Pahang Volcanic Series. Among the sediments are claystones with Stephanian plants, *Pecopteris* and *Calamites*, but no fossils comparable with those of the Malayan Visean have been found. No Carboniferous or Permian has yet been recognized in the Philippine Islands.

SIAM.—In Siam, Newton (1916, p. 62) recorded a dark crystalline limestone having a small fauna with one brachiopod, *Dielasma* sp., which was considered to be of Lower Carboniferous age owing to the absence of *Schwagerina* and *Fusulina*. This deposit occurs in the Upper Menam Valley, 200 miles north of Bangkok. A second deposit consisting of a fine grained siliceous rock of chalky appearance in the Patalung district of Siam was described by T. McKenny Hughes (1901), and the fossils by F. R. C. Reed (1916, and 1920, p. 113), who considered them to be of Culm age. The brachiopods are comparable with those of the Culm of Germany, and of Devon, as described by Bather in 1895, but are totally distinct from any of the Malayan specimens. Some of the shales of the lower division below the limestones of the Perlis district were compared by Scrivenor (1931) with the shale of Patalung, Siam. This locality is about fifty miles north of the most northerly part of the Perlis outcrop and is on the same line of strike.

BURMA.—No true Lower Carboniferous has yet been recorded from the Shan States, Burma, although it may be included in the unfossiliferous Lower Plateau Limestone which is said by Chhibber (1934) to be of Silurian to Carboniferous age. The Upper Plateau Limestone above is Permian and contains some species characteristic of the Upper Permian of the Salt Range, India. Another deposit, the Moulmein Limestone at Tenasserim, Siam, just north of Malaya, contains *Schwagerina*, and is probably of Uralian¹ or later Permian age. Underlying this, conformably in one district only, is the Mergui Series of unfossiliferous grits, shales, and agglomerates, the age of which is uncertain and may be Precambrian. Scrivenor, however, in 1934 (in Chhibber, p. 186) suggests that this series may equal the Malayan Trias and Lower Carboniferous.

INDO-CHINA.—Lower Carboniferous is found in Indo-China in Tonkin, Annam, Laos, and Cambodia, but the beds are much folded and faulted, and the fossils are not numerous and are poorly preserved in marls, schists, or limestones. Fromaget (1927) records *Productus giganteus*, *Tylothyris* cf. *laminosa* and *Phillipsia* from the northern part of central Indo-China, but gives no figure of the spiriferid, and it is not known, therefore, whether it is comparable with *Punctospirifer pahangensis* sp. nov. from Malaya. Imperfect specimens of *Productus* [*Krotovia*] *spinulosus* J. Sow. recorded by Deprat (1912) and figured by Mansuy (1913a and c) from Thanh-ba region, Tonkin, and Montagne de l'Eléphant, near Haiphong, may be compared with *Krotovia* cf. *multituberculata* (Yan.) of Malaya. No other species of Indo-China are comparable with those of the Malayan limestones. The Indo-China deposits are assumed by Mansuy (1913c, 1919a), Wong and Grabau (1924), and Hoffet (1933) to be of Visean age, while Moscovian, Uralian, and Permian are also developed; the last, containing species found in the Salt Range, India, and in south China, is described by Mansuy (1913b, 1914b).

YUNNAN, CHINA.—Farther north in eastern Yunnan, Lower Carboniferous fossils have been described by Mansuy (1912, 1914a, and 1919a and b), and Deprat (1912) from several localities. Five distinct horizons were recognized by Mansuy in 1912, the beds being schists and marls, and the fauna is considered by Wong and Grabau (1924) to be Visean.

The only comparable form from eastern Yunnan is *Linoproductus tenuistriatus* (de Vern.) figured by Chao (1927, p. 135, pl. xiv, fig. 5) from the Visean of Tung-Shan, Chang-Yi, Yunnan. This is the only species listed (p. 174) from this locality, but *Gigantella gigantea* has been recorded by Chao (1927) from adjacent regions, and the deposit may be of Upper Visean age.

¹ In this work the term Uralian [=Sakmarian of the U.S.S.R.] is used to signify beds containing "*Schwagerina* [*Pseudoschwagerina*] *princeps*" which are taken to be of Lower Permian age.

Another distinct Visean fauna occurs in western Yunnan and one species, *Lino-productus yunnanensis*, first described from Ta-shih-wo by Loczy (1897) is also found in Malaya at Bukit Sagu. Dr. Coggin Brown later (1916) collected a small Visean fauna at this same western Yunnan locality, about longitude $99^{\circ} 12' E.$ and latitude $25^{\circ} 5' N.$, and the fossils have been described by F. R. C. Reed (1924, 1927). The matrix is described as a dark grey massive crystalline limestone which yielded among other species *L. kokscharensis* (Gröber), in addition to *L. yunnanensis*, both occurring in the Malayan limestones. The precise horizon of the Visean in western Yunnan is uncertain and *Gigantella gigantea* does not occur.

CHINA.—In China the Lower Carboniferous, or Fengninian, is divided into four zones by means of the predominating corals by Yü (1931, 1937). These are: (1) *Cystophrentis* zone (= *Zaphrentis* zone) in Hunan, (2) *Pseudouralinia* zone with Kinling limestone in Kiangsu and Anhui (= *Caninia* zone), (3) *Thysanophyllum* zone with the Chiussu Sandstone of Kweichow (= *Seminula* zone), (4) *Yuanophyllum* zone (= D_1 up to Yoredales). The upper part of the *Yuanophyllum* zone contains *Aulina* and is said to be equivalent to D_2 - D_3 subzones. Zones 1 and 2 form the Lower Fengninian = Tournaisian, while zones 3 and 4 form the Upper Fengninian or Visean.

Ting (1931) proposed a second classification and substituted the terms Kolaoho Series for *Cystophrentis* zone, Tangpakou Series for *Pseudouralinia* zone, Chiussu Series for *Thysanophyllum* zone, and Shangssu Series for the *Yuanophyllum* zone.

Ting and Grabau (1934), however, divide the Fengninian into Lower F. = 1 and 2 of Yü, Middle F. = *Thysanophyllum* zone (in part) or Chiussuan, and Upper F. including the upper part of the *Thysanophyllum* zone upwards.

Comparatively little is known about the brachiopods of China, and several monographs advertised to appear in *Palaeontologia Sinica* have not yet been published. Comparison of the Malayan specimens with species described by Chu (1933) from the Kinling Limestone of the *Pseudouralinia* zone of Kiangsu, Anhui and Szechuan, failed to show any forms in common.

No figures have been published of forms from the Chiussu Sandstone, but Ting and Grabau (1934) list *Productus yunnanensis* from this horizon (= *Seminula* zone) in south Kweichow. It is uncertain, however, if this species has been correctly identified, though from Cowper Reed's description (1927) it would appear to occur in the Visean below the *Dibunophyllum* zone in western Yunnan. Yabe and Hayasaka's figures (1920, pl. xxvi, fig. 5) of this species from the Upper Carboniferous or Permian of Wei-ning-hsien, Kweichow, show a totally different form, belonging either to the genus *Gigantella* or to *Kansuella*.

The Upper Fengninian which yields numerous brachiopods contains *Gigantella gigantea*, *G. edelburgensis*, and other forms typical of the European Visean. Some species are comparable with those of Malaya, especially those of the Choniukou Limestone of Kansu in north-west China which represents the top beds of the *Yuanophyllum* zone. The Upper Visean sea was transgressive and deposits occur in Yunnan, Kweichow, Kwangsi, Hunan, in south China; western Tsinling, Shensi; in the Nanking Hills, Kiangsu; as well as in Kansu in the north-west, where the Visean forms the lowest fossiliferous strata (Yuan, 1925). *Linoproductus tenuistriatus* (as figured by Chao, 1927, pl. xiv, figs. 5, 9-12) is common to the Malayan limestones and the Choniukou Series of Kansu, and *Spirifer* sp. (*striatus* group) of Malaya may equal *S. liangchowensis* Chao.

The Fengninian fauna collected from different horizons in central Hunan and described by Ozaki (1939) did not yield any forms comparable with those of Malaya. Specimens of *Gigantella edelburgensis* (Phill.) were obtained, however, by Ozaki from the top beds or Tzemenchiao Limestone which must, therefore, be of Visean age.

It is probable that when more of the species at present listed as MS. species from

the *Yuanophyllum* zone have been described and figured they will be found to be identical with the Malayan forms. Many of the Chinese faunas recorded by Frech (1911) and other authors as Lower Carboniferous have proved to be Moscovian, Upper Carboniferous, or even Permian.

JAPAN.—The Lower Carboniferous in Japan is frequently represented by coralline or crinoidal deposits (Hayasaka, 1936, and Yabe, 1940). The best development is at Omi-mura, province of Echigo, western Japan, whence the fauna has been described by Hayasaka (1924). Tournaisian and Visean are represented by a thick limestone, the upper part of which is of Uralian and Permian age. Two species are common to Omi-mura and the Malayan Limestones, *Pugnax acuminatus*=*P. asiaticus* sp. nov., and *Spirifer* [*Choristites*] *humerosus*. The most interesting species is the *Pugnax*, which appears to be similar to the specimens of *P. asiaticus* from Bukit Tinggik. Unfortunately the precise horizon of these species at Omi-mura is uncertain and *P. "acuminatus"* is said to be from beds which may be Upper Tournaisian to Upper Carboniferous in age.

INDIA.—Turning to India, Lower Carboniferous beds occur in the Himalayan region and are represented by the Lipak Beds of Kanaur and Spiti and by the *Syringothyris* Limestone of Kashmir. These beds are described by Hayden (1904) and Middlemiss (1910) and the fossils are figured by Diener in 1899, 1903, and 1915. Hayden (1904, p. 3) described the Carboniferous beds of Spiti as overlying the white Muth Quartzite now considered to be of Silurian age. In the valley of the River Lipak, Kanaur, central Himalayas, the Muth Quartzite is overlain by limestone and quartzites 2,000 ft. thick =Lipak Series, and these beds are followed by dark shales and quartzites of the Po Series (Burrard and Hayden, 1908). Near Po this series passes up into a conglomerate and grits, and then to the calcareous sandstone below the Productus Shales. These grits and calcareous sandstone, together with the Productus Shales, are of Upper Permian age.

In Kashmir the Muth Quartzite is succeeded by a thin bedded flaggy limestone known as the *Syringothyris* Limestone, which is equivalent to the Lipak Series and of Lower Carboniferous age. This limestone is followed by unfossiliferous quartzites and shales, and then by the *Fenestella* series, now correlated with the upper part of the Po Series or *Fenestella* Shales of Kanaur and Spiti. The *Fenestella* Shales and Po Series are considered to be of either Middle or Upper Carboniferous age (Burrard and Hayden, 1934).

Careful comparison of the Malayan fossils with these fossils from the *Syringothyris* Limestone and the Lipak Series also with those of the *Fenestella* Shales failed to show any species in common. From analogy with other areas it seems probable that only Tournaisian Beds are represented in the Himalayas. It is possible that the Visean, if developed, in India may be represented in part by the Mount Everest Limestone, which is considered by Muir-Wood and Oakley (1941) to be of Devonian and Lower Carboniferous age.

TIBET AND MONGOLIA.—No Lower Carboniferous has so far been found in Tibet, and no species comparable with those of Malaya were described by Venukoff (1888, 1889) from the Visean of Bardoun, Inner Mongolia, just north of Kansu; or from Sair-Usu, central Mongolia by Berkey and Morris in 1927. Lee (1939), however, records *Gigantella* cf. *gigantea* from the Sair Usu Beds of Mongolia, thus suggesting the existence of Upper Visean in this region.

SIBERIA.—Lower Carboniferous occurs in the Kuznetzk coal-field, Altai, Siberia, south of the Trans-Siberian Railway, about 87° longitude, 53° 30' latitude near the Salair Range, whence the fauna was described by Rotai (1938), and Tolmachoff (1924, 1926, 1931), and Fomitchev (1940). The Tournaisian and Visean are both developed, but *Reticularia imbricata* seems to be the only species in common with the Malayan limestones. Farther north-east, near Tomsk, argillaceous schists and grits on the Tom River have yielded a

small fauna described by Yanishevsky (1915) as of Visean age. Tournaisian beds also occur in this district. One Visean species, *Spirifer sibiricus* Yan. (non Lebedev) is renamed *Spirifer derjavini* by Yanishevsky (1918), and occurs also in Ferghana and Malaya, though the Ferghana specimen is in closer agreement with the Malayan forms. The small Lower Carboniferous fauna described by Popov (1938) from a tributary of the River Lower Tunguska, which joins the northward-flowing River Yenissei in Siberia, is probably of Tournaisian age.

TIAN-SHAN, TURKESTAN.—Farther south-west, according to Gröber (1908, 1909), Leuchs (1912), Krenkel (1913), Keidel (1906), Yanishevsky (1928), Vakhrameiev and Smirnov (1939), and Sokolov (1940) Carboniferous limestones, sandstones, and slates occur with an Upper Visean fauna in north, central and eastern Tian-shan, and in some of the inner mountain ranges. According to Krenkel (1913), these marine beds occur in west Tian-shan in the Dzungaria Alatau Mts., the Barlyk Mts., in south Tian-shan in the Yulduz region, at Utsch-turfan, Basch-tschakma, and in central Tian-shan in Khalyk-Tau Range, also near the Sart-dschol Pass, south of Karkara. Two horizons have been recognized, the lower or Tournaisian beds which are rarely seen and are conformable on the Upper Devonian in western Tian-shan, while the higher or Visean beds with *Productus giganteus* are considered by Gröber to be equivalent of the Upper *Dibunophyllum* zone. Krenkel states that the *Seminula* zone has not yet been recognized. The Upper Visean beds contain a rich brachiopod fauna, and the following species occur also in Malaya: *Linoproductus kokdscharensis* (Gröber), *L. "tenuistriatus"* (de Vern.), *Pugnax acuminatus* (? = *asiaticus* sp. nov.), *Spirifer bisulcatus* (? = *Brachythyris willbourni* sp. nov.).

According to Yanishevsky (1928) there are two horizons in the Visean beds: (1) with *Productus giganteus* fauna, (2) with *P. edelburgensis* and *P. kokdscharensis*. The *Spirifer bisulcatus* beds immediately overlying (2) are said to be Moscovian. Three of the species listed above are said to occur in the *P. edelburgensis* bed at the top of the Visean in central Tian-shan in the Terskei Alatau, south of Karkara, while the fourth, *Pugnax acuminatus*, occurs in the equivalent of the D_2 beds in southern and eastern Tian-shan, and especially at Basch-sugun, north-east of Kashgar, Chinese Turkestan. *Spirifer bisulcatus* of the beds immediately overlying the Visean was re-identified by Semichatova (1938b, 1941) as *Choristites* ex gr. *bisulcatiformis*. The beds it characterizes are described as Bashkirian Beds, which are said to be the lowermost part of the Moscovian. Vakhrameiev and Smirnov (1939) discuss the distribution of these beds in Tian-shan, Ferghana, and the Urals, and state that they are separated from the Upper Visean by a series of rocks, often unfossiliferous, which may be equal to the Namurian.

Only one species, *Dictyoclostus* cf. *deruptus* (Romanowsky), has affinities with a species from the lower beds of Tian-shan and Turkestan. *Productus deruptus* was described from the banks of the River Kosch-Karat, south-east of the Kara-Tau Range, Turkestan, and was recorded from the Upper Tournaisian of the Chatkal Mts., Ferghana, by Dikareva (1937), and from the Lower Visean, Ishim Beds of Kazakhstan, by Nalivkin (1937). Romanowsky's specimens (1880) of *Spirifer bisulcatus* from near the River Borgusta in Kuldja, Chinese Turkestan, also appear to be similar to *Brachythyris willbourni* sp. nov. of Malaya.

Löweneck (1932) described the localities in Tian-shan whence an abundant Lower Carboniferous fauna of brachiopods and molluscs was obtained by a number of expeditions. Only Upper Visean is said to occur in this region and lower beds are only found in the west in the Kara-Tau Range and Alai Mts. These upper beds occur at Basch-sugun, Tongitar, Kysil-bulakning-saie, Utsch-turfan, Denededawan, Basch-tschakma in southern Tian-shan; at Santasch Pass, Sart-dschol Pass, Aktasch, Mukurmutu Valley, and Jagas-su in central Tian-shan; at Kasan and Koktal Valleys, Chonochai and Altuin-Tau in northern Tian-shan; and at Chodschur-noe-ussun and the Yulduz Valley in eastern Tian-shan.

The following species figured by Löweneck are comparable with Malayan forms: *Retzia* (= *Hustedtia*) *radialis* (Phill.) from Basch-sugun (pl. i, figs. 11 a-c), also recorded from Chonochai, Jagas-su; *Brachythyris buckmani* Yan. from Basch-tschakma; *Schizophoria resupinata* var. *baschsugensis* Löweneck (= *S. mesoloba* Yan.) from Basch-sugun; *Linoproductus kokdscharensis* (Gröber) from Yulduz Valley, and also from Sart-dschol and Ischtyk Pass. The following species found in Malaya have been recorded from the Upper Visean of Tian-shan by Löweneck: *Leptaena analoga* (Phill.), *Echinoconchus elegans* (M'Coy), *Productus margaritaceus* (Phill.), *Krotovia spinulosa* (? = *multituberculata* Yan.), *Linoproductus tenuistriatus* (de Vern.), *Pugnax acuminatus* (Martin) (? = *asiaticus* sp. nov.), *P. pugnax* (Martin). In addition to *Gigantella gigantea*, *G. edelburgensis* and other species, *G. latissima* (Sow.), *Krotovia multituberculata* (Yan.), *Echinoconchus elegans* (M'Coy), *Schizophoria resupinata* (Martin), and *Leptaena analoga* (Phill.) were recorded by Sokolov (1940) from the Upper Visean (= D₂-D₃ subzone) of central Tian-shan. These beds extend from west of Lake Son-kul to Khan Tengri and Khalyk-Tau Ranges in Sinkiang. This fauna is said by Sokolov (1940) to equal the Serpukhovian of Russia, while the corals of these beds include a number of forms of the *Yuanophyllum* zone of China.

FERGHANA, RUSSIAN TURKESTAN.—The most closely allied Asiatic fauna occurs farther west in Ferghana, Russian Turkestan, where fourteen of the Malayan limestone species are at present known to occur. Lower Carboniferous, Visean beds with *P. giganteus* and *P. tenuistriatus*, have been described from the Margelan and Kokand districts by Weber (1910), and from near the town of Osh by Mouchkétov (1915), from the Chatkal Mts. by Dikareva (1937), from the Tuya-mooyoon region of eastern Ferghana by Komishan (1927), and from various localities in Ferghana by Yanishevsky (1918), by Vakrameiev (1938), and by Meyer (1910). The following species described by Yanishevsky (1918) occur also in the Malayan limestones: *Schizophoria mesoloba* Yan.; *Linoproductus kokdscharensis* (Gröber); *L. "tenuistriatus"* (de Vern.); *Avonia weberi* Yan.; *Krotovia multituberculata* (Yan.); *Marginicinctus planus* (Yan.); *Proboscidea* sp. and *P. proboscidea* (in part = *P. nana* sp. nov.); *Pugnax* cf. *pugnax* (Martin); *Reticularia elliptica* (in part = *R. cf. alexandri* George from Malaya); *Spirifer duplicicostus* (= *Spirifer scriwenori* sp. nov. of Malaya); *Spirifer derjawni* Yan.; *Spirifer bisulcatus* (in part = *Brachythyris wilkbourni* sp. nov.); *Brachythyris buckmani* Yan. Another species, *Brachythyris kokuensis* described by Dikareva from the D₂ subzone of the Chatkal Mts., Ferghana, also occurs in Malaya. Three other specimens of the Malayan limestones have been compared with Ferghana species—*Gigantella* cf. *latissima* (Sow.), *Dictyoclostus* sp., and *Cyrtina* sp. of Yanishevsky, the last resembling *S. cf. condor* d'Orb., of Malaya.

Yanishevsky's fauna unfortunately is described in Russian, but apparently (1928) he considered the species to be Visean though they may be from more than one horizon. He referred to the *P. giganteus* beds at Narynsk, east of Ferghana as being similar to those near Lake Son-kul and near Tchimbkent in Kazakhstan which have been referred to under Turkestan (p. 14).

In the Chatkal Mts. Dikareva (1937) gave the sequence as Lower and Upper Tournaisian, followed by Lower Visean and Middle Visean with *Productus striatus* Fischer and *Brachythyris kokuensis* Dikareva. The Upper Visean beds of the Chatkal Mts. are doubtfully correlated with Namurian.

Sergunkova (1935, 1937) in a description of the Tournaisian and Lower Visean beds of the Talassic Alatau Range, Tian-shan, does not describe any species comparable with Malaya, but correlates the Lower Visean beds of the Talassic Alatau Range; of the Chatkal Mts., Ferghana; of Narynsk, Tian-shan; and the Yagovkin Beds of north-east Kazakhstan, with C₂, S, and D₁ of the south-west Province of England. It is assumed, therefore, that most of the comparable fossils of Ferghana are from the equivalent of the D₂ subzone.

NORTH KAZAKHSTAN.—Tournaisian and Visean species have also been recorded from near the Ishim River, Kazakhstan, north-west of Ferghana by Andronov (1937), Andronov and Iliina (1939), and from near Lake Balkhash by Nalivkin (1937), but most of the forms are still undescribed. The Upper Visean beds are overlain conformably by Namurian and Lower Moscovian, and the fossils from these horizons are listed together, but none of these forms appears to be comparable with the Malayan limestone species. *Gigantella* first occur in the lower *Seminula* zone in Kazakhstan, but appear to be distinct from *G. gigantea*. In Nalivkin's (1937) description of the Lower Carboniferous of north-east Kazakhstan near Lake Balkhash, the Visean beds are subdivided into Ishim below and Yagovkin beds above, the latter containing a *Spirifer* identified as *Spirifer logani* which is closely allied to *Spirifer scrivenori* sp. nov. of Malaya. *S. logani* is recorded from Dzezakzgan district. *Spirifer* aff. *integricostus* Phill. from the same locality is comparable with *Brachythyris willbourni* sp. nov. *Gigantella edelburgensis*, *Sinuatella sinuata*, and other species occur in the Upper Visean limestones south of Karsakpay immediately below the Dzezakzgan Series of sandstones, shales, and conglomerates of either Upper Visean or Lower Namurian age (Sapozhnikov, 1938).

IRAN.—Farther west in Asia Lower Carboniferous beds have been recorded in northern Iran by Blanford (1876), Douvillé (1904a and b), Stahl (1911), Rivière (1934), Clapp (1940), and Furon (1941). Clapp states that both Tournaisian and Visean beds occur in eastern Iran, in north-west Khorasan; in the Shah Abdul Azim Mts., south-east of Teheran, and in the Elburz Mts. In the latter region *Gigantella gigantea* occurs, but the rest of the fauna is imperfectly known. Böckh, Lees and Richardson (1929, p. 120) record a dark limestone with Cyathophylloid corals, one of which has been identified by Dr. Stanley Smith as *Orionastraea* and probably of Lower Carboniferous age from fourteen miles north-east of Hamadan, and about 150 miles south-west of Teheran. No brachiopods were recorded from this exposure.

ARMENIA and ASIA MINOR.—The Visean *P. giganteus* beds outcrop again in the Araxes Gorge in Armenia, and *Productus* [*Krotovia*] *keyserlingianus* de Kon. recorded from this region also occurs in Malaya. The same beds occur at Eregli [Heraclea] on the shores of the Black Sea, in the Taurus Mts., and Ante Taurus of south Asia Minor, but the only comparable species is *Spirifer bisulcatus* (Frech, 1916, pl. iii, fig. 7) from Belededik, Taurus, which closely resembles *Brachythyris willbourni* sp. nov., of Malaya. The fauna described by Frech and Arthaber from Armenia and Persia in 1900 is now recognized as Permian.

BALKANS.—Lower Carboniferous, Visean beds with a D_2 fauna including *Gigantella latissima*, *G. edelburgensis*, *Spirifer striatus*, occur in west Serbia at Ivovik, while a more specialized fauna of Visean age occurs at Sarajevo, Bosnia (Heritsch, 1939), with no species comparable with those of Malaya.

AUSTRIA.—The Visean *P. giganteus* beds crop out again in south Austria at Nötsch in the Gail Valley with *Buxtonia scabricula*, *Gigantella latissima*, and other species (Heritsch, 1939).

U.S.S.R.—Few Malayan species occur in the Lower Carboniferous beds of Russia. *Schizophoria mesoloba* Yanishevsky (1900) originally described from the Upper Visean C_1 (e) of Schartymka River, south of Miask, east Urals, occurs also in the Visean of Ferghana and in the Pahang limestones. *Spirifer scrivenori* sp. nov. is closely related to *S. lutugini* Rotai (1931) from the Beschevo Limestone, at top of C_1^3 , of Geological Committee (= D_3 subzone) of the Donetsk Basin, while *Reticularia* cf. *alexandri* George from Malaya is similar to *R. beschewiana* Rotai from the same horizon. The Lower Carboniferous, Visean, of the Donetsk Basin has been subdivided into five zones with the Mandrikino Beds at the top and the Beschevo Beds underlying them. Both these horizons contain *Gigantella gigantea*. *Productus latissimus* is found in the Beschevo Limestone, and in the

beds immediately below which are equivalent to the C_1^2 horizon of the Geological Committee, or D_2 subzone.

Linoproductus tenuistriatus (de Vern.) is figured from the Upper Visean Serpukhovian, C_{3p}^4 near Kremenskoye, Moscow Basin, by Sarytcheva (1937), the specimens being identical with the largest form from Bukit Charas, Malaya.

From the above correlations it is evident that the Malayan limestone fauna is of Visean, probably D_2 age, with the possible exception of *Linoproductus yunnanensis* (Loczy) and *Dictyoclostus* cf. *deruptus* (Rom.), which may be from slightly lower beds.

AMERICA.—There is no evidence of a close connection between the Malayan sea and that of western North America, and with the exception of *Spirifer* cf. *condor* d'Orb. none of the limestone forms has been compared with American species. *Spirifer condor* d'Orbigny occurs in the "Upper Carboniferous" (Lower Permian) of Bolivia, Texas, and has also been recorded from the Uralian of Timan, North Russia. As nothing is known of the internal structure of the Malayan specimens it is not possible to state if their resemblance to the South American species is more than superficial.

The Malayan spirifers, however, are more closely related to Asiatic Uralian and Permian species of which they are probably ancestral forms, and to Permian spirifers of North America, than to species of the European Visean.

Pugnax asiaticus sp. nov. belongs to the group of *P. acuminatus* (Martin) from the European Visean, and the latter species is frequently recorded from the Visean of central Asia, Ferghana, Turkestan, as well as from the Beschevo Limestone (= D_3 subzone) of the Donetsk Basin, south Russia, but no comparable form occurs in the North American Carboniferous.

Linoproductus "tenuistriatus" (de Vern.) affords a definite link with eastern Yunnan, Kansu, Tian-shan, Ferghana, and the Moscow Basin.

B.—AGE OF SHALE AT SUNGEI TERAPAI

The relation of the shale fauna to that of the limestones is entirely unknown, and there are no similar species. The presence of drifted plant remains suggests near shore conditions and the few marine species, all of which are small forms, may indicate a restricted area of deposit.

The plant remains occur in a bed of approximately the same age as the marine fossils, and a crinoid ossicle was actually associated with some of the plant fragments. These specimens have been examined by Mr. W. N. Edwards, who has described them in an appendix (Pt. IX) to this work. Owing to the imperfect state of preservation of the material no specific determination was possible. All the specimens are lepidodendroid and give no indication of age.

By far the most interesting fossils from Sungei Terapai are seven specimens of trilobites which have been described by Dr. C. J. Stubblefield in Part XII of this work, and are considered by him to be of Lower Carboniferous age.

Bryozoa remains are abundant but poorly preserved, and are identified by Dr. K. P. Oakley (Part X) as *Fenestella* spp., *Fistulipora* sp., *Cystodictya* sp. Only one lamellibranch is included in this collection and no gastropods or cephalopods occur. Crinoid ossicles are abundant, but are not sufficiently well preserved for accurate determination. Mr. L. Bairstow has identified them as "*Poteriocrinus*" sp., but they give no indication of the age of the rock.

The brachiopoda consist only of the following species: *Schizophoria* sp., *Leptaena* cf. *analogia* (Phill.), *Chonetes* sp., *Dictyoclostus* cf. *parvus* (Meek & Worthen), *Echinoconchus*

elegans (M'Coy), *Productina margaritacea* (Phill.), *Hustedia* cf. *radialis* (Phill.), *Punctospirifer pahangensis* sp. nov., the last-named species predominating. All the specimens are imperfectly preserved and consist mainly of single drifted valves. The resemblance is again to British rather than to Asiatic species, and no comparable fauna has been described from adjacent regions.

The specimens of *Schizophoria* differ from those of the Malayan limestones and do not yield any indication of age, as species of this genus occur in both Tournaisian and Visean of Asia.

The *Chonetes* is too poorly preserved for specific determination and the specimens of *Leptaena*, which differ slightly in ornament from *L. analoga* of the British Carboniferous, may be either Tournaisian or Visean. Comparable forms do not occur in the Middle and Upper Carboniferous, or Permian, of Asia. In ornament it resembles most closely *L. sinuata* Demanet (non de Kon.) from the Visean of Visé, Belgium. It can be compared also with a specimen figured by Reed (1927) from the Visean of western Yunnan, and with Mansuy's (1913d) specimen from the Visean of Nong-Po, Tran-ninh, Laos, Indo-China.

Dictyoclostus cf. *parvus* (Meek & Worthen) resembles specimens from the Upper Mississippian of Chester, Illinois, but cannot at present be matched in Asia, while *Productina margaritacea* (Phill.) resembles the British species which occurs in the D₂ subzone. It also resembles a small form figured by Yanishevsky (1918) from the Visean of Ferghana, and a larger specimen from the Beschevo Limestone of the Donetz Basin, south Russia (=D₃ subzone according to Rotai, 1931).

The specimens of *Echinoconchus elegans* (M'Coy) can be compared with specimens of the Choniukou Limestone (=D₂ subzone) of Kansu, north China, already referred to under the limestone fauna, and with specimens figured by Yanishevsky (1918) from the Visean of Ferghana, Russian Turkestan; by Hayasaka (1924) from Omi-mura, Echigo, Japan; and by Reed (1927) from the Visean of Ta-shih-wo, western Yunnan.

Hustedia cf. *radialis* (Phill.) closely resembles specimens of this species from the D₂ subzone of Yorkshire, Derbyshire, and Staffordshire. In Asia *Hustedia* occurs more commonly in the Upper Carboniferous and Permian than in the Lower Carboniferous. Yanishevsky (1918), however, figured two specimens from the Visean of Ferghana which are comparable, and two smaller examples from the Visean of Tomsk, Siberia (Yanishevsky, 1915), while Loczy (1897) figured a similar form from [the Visean of] Kansu, north China.

Punctospirifer pahangensis sp. nov., which is represented by numerous detached valves, is most closely allied to *P. scabricostus* mut. *ashfellenensis* North and mut. *redesdalensis* North from the British S₂ and D₁ beds respectively. No British Tournaisian species are known. In Asia no *Punctospirifers* have yet been described, but from published figures this genus seems to occur in the Visean only. It is found in the Lower and Upper Mississippian of America as well as in higher beds. *Spiriferina laminosa* and *S. salemensis* Weller [? *Punctospirifer*] were recorded from C₁^{2c} horizon of the Ishim River, Kazakhstan, which is said to be equivalent to the *Seminula* zone; while *Spiriferina transversa* (McChesney), probably a species of *Punctospirifer*, occurs in the upper part of the Visean of the same region.

From the above evidence the Sungei Terapai brachiopods would appear to be of Lower Carboniferous, Visean age, but the Sungei Terapai graphitic shale may be older than the limestone of Bukit Tinggik, Bukit Sagu, and Bukit Charas.

VI. PALAEOGEOGRAPHY OF THE LOWER CARBONIFEROUS, VISEAN, OF ASIA

(Plate XVII)

The remarkable similarity of the Malayan limestone fauna to that of Ferghana, Russian Turkestan, and to a lesser extent to the western European Visean, suggests a direct connection between the Lower Carboniferous seas of these regions. This could not have been by way of the Himalayas and Tibet, where no Visean fauna has yet been found, but was probably by Siam; Indo-China; western Yunnan; Kweichow in south China; Tsinling in Shensi, Kansu, north-west China; by the Nan-Shan geosyncline, Chinese Turkestan [Sinkiang]; Tian-shan, where the sea appears to have been widespread, to Ferghana. From Ferghana the sea must have extended westwards by way of northern Iran, Asia Minor, through northern Hungary and the eastern Alps, Poland, Germany, Belgium, France, and Great Britain.

The distribution of the Tournaisian of Asia differs considerably from that of the Visean, though the area covered by the two Lower Carboniferous seas was probably about equal in size. Towards the end of the Tournaisian the sea shallowed and withdrew from large areas, such as Siberia, Mongolia, and the Kirghiz Steppe, which became largely continental in Lower Visean times. A great transgressive invasion of the sea from the south-west occurred in Upper Visean times and some regions that had previously been continental were now submerged. This sea brought with it an Indo-Pacific type of fauna, largely consisting of Visean forms, and contrasting with the Boreal or Mississippian type of fauna of North America.

The palaeogeography of the Lower Carboniferous of Asia has been discussed by several authors: Tolmachoff (1926, 1931), Frech (1911), Yanishevsky (1928), Ting and Grabau (1934), Wong and Grabau (1924) and Grabau (1924). Additional discoveries, as well as more accurate zoning and revision of faunal lists, require some modifications of the maps in the two last-named papers of the distribution of sea and land in Visean times. According to these authors sea extended just south of the coasts of Arabia, Iran, India, Ceylon, Siam, Sumatra, and Java. The extension of this sea eastwards is not seen, but sea is shown extending northwards just east of the Philippine Islands and Korea and covering Japan and part of the Bering Sea. A narrow strait is shown extending westwards from the north of Japan and southern part of Sakhalin Island across Manchuria, Mongolia, south of Lake Baikal, and Siberia [Angara Land], and north of the land region of the Gobi desert to the Kuldja district of Chinese Turkestan, where the sea is shown to widen considerably to include Tomsk in Siberia and southwards to Ferghana. A narrow strait is shown extending eastwards from Turkestan north of the Tibet land mass to south China and along the Yangtse Valley, while a second strait south of Tibet along the Himalayan geosyncline unites with the south China Sea and extends to Indo-China. There does not, however, appear so far to be any evidence for the existence of Visean deposits in Manchuria, and the adjoining parts of Inner Mongolia. Archangelsky, however (1939), in a palaeogeographical map of the Visean, and Gregory and Barrett (1931, fig. 20) also show a west to east gulf extending over Manchuria and part of Mongolia from the sea covering Japan.

The extension of the Malayan Tethyan sea southwards, and south-eastwards, and the position of the northern shore of the great Gondwana land mass is unknown. It is probable that sea covered part of Sumatra, and thence stretched eastwards to the eastern coast of

Australia, which, for a brief period at least, was submerged in the Visean sea (Benson, 1923 and 1924). Three marine fossiliferous horizons are known to occur in the Burindi Beds (Tournaisian) of New South Wales, while one marine horizon has been recognized in the Lower Kuttung (Visean) beds of the same region. Beds containing similar corals as the Lower Kuttung are said by Carey (1937), quoting Dr. D. Hill, to occur in the Lion Creek Limestone and Stanwell and Riverleigh Limestones of Mundubberah, Queensland, farther north. Carey suggests that this Lower Kuttung marine bed may have represented an interglacial period since glacial boulder beds occur both above and below this horizon, while the rest of the Visean formation is represented by continental plant-bearing beds and lavas. Süssmilch stated (1922) that an ancient land area, Tasmantis, extended over Tasmania and those parts of New South Wales and Queensland which were cut off from the rest of Australia by the Lower Carboniferous sea. As no Lower Carboniferous beds occur in New Zealand, it is probable that the Visean sea did not extend far south-eastwards from New South Wales.

No trace of glacial beds has been found in the East Indies islands, nor is there yet any proof that they were submerged in the Visean sea.

From the identity of the coral genus *Echigophyllum* from the Lower Carboniferous ?Visean of western Japan with the genus *Amygdalophyllum* of New South Wales, it is possible that the Australian sea may have extended northwards and east of the Philippine Islands, as shown by Grabau (1924), to Japan, and northwards to Alaska, and so to the western coast of North America as far south as California, whence species with Chinese, Fengninian, affinities have been recorded in the Baird Shales (Smith, 1894 and Grabau, 1932a). Grabau suggests that this connection was west of 106° longitude, and continental plant-bearing beds in Melville and Bathurst Islands may represent the barrier between the Pacific and Mississippian faunas. According to Tolmachoff (1931) the Baird Shales of California, and the Lisburn Limestone of Alaska, both contain *Productus giganteus* and an Old World or Indo-Pacific fauna, distinct from the Mississippian or Boreal fauna.

From Malaya the Visean sea probably extended northwards over parts of Siam (Högbom, 1914), and Indo-China, where the difference in fauna may be explained by difference of facies, marls, and shales predominating in both these countries, with a typical European Culm-type of deposit in part of Siam. There is no evidence of the occurrence of marine Lower Carboniferous beds in Burma, and it is possible that the north-to-south land barrier which Grabau (1934) suggested may have existed in the Middle Permian at 103° longitude may have already been formed. Grabau explains the disappearance of the *Gigantopteris* flora of China as it is traced westwards in Yunnan by a land barrier at about 103° longitude. Marine beds intercalated with the *Gigantopteris* series disappear farther east at about 106° longitude. At 103° longitude red shales and sandstones overlying basalts are said to indicate a belt of high land running from north to south into Indo-China and about 2½° longitude wide. In the south the ridge is said to be represented by great thicknesses of rhyolites. The *Gigantopteris* flora occurs in Malaya and Sumatra, but the *Glossopteris* flora of India and Gondwanaland is not represented at all in Malaya or south China, and this north-to-south ridge is said to be the dividing line between the two floras.

The sea which extended over the Himalayan region in Tournaisian times was apparently no longer in existence in the Visean. Tibet was also a land mass, and may have been united during the Visean with Peninsular India and Gondwanaland.

In the western Kwenlun Mountains, north of Tibet, de Terra (1932) described the Tisnab group of coarse clastic deposits and volcanic outpourings as being of continental origin, and of probable Middle Lower Carboniferous age. Marine beds equivalent to the Basch-sugun Series of west China are said by Grabau (1932b) to be Visean, but these are probably equivalent to the Penchi Series of China which is usually regarded as Middle

Carboniferous. The Visean appears to be absent except in the region of Kashgar and the Tekelik-tagh Mountains south of Chotan. The exact age of the Carboniferous beds with "*Saccamina*" *carteri* recorded by Schellwien (1903) from the Upper Hoang-ho River, north-eastern Tibet, is uncertain, but they may be Visean. Elsewhere in Tibet the Lower Carboniferous appears to be absent. Visean beds occur in both eastern and western Yunnan, whence the outcrop extends towards the north-west. It is possible that this Yunnan sea may have connected directly with the Nan-Shan geosyncline of north-western Kansu round the eastern end of the Tibet land mass, or the connection may have been by south Kweichow and central Hunan, where the Visean is represented by the Lower Tzemenchiao Limestone with a rather similar fauna to that of the Choniukou Limestone of Kansu. This connection of south China and Turkestan was in existence in Tournaisian times according to Ting and Grabau (1934) for species of the Kinling Limestone of China occur in the Richthofen Mountains of Kokonor to the north of Tibet; in Chinese Turkestan, as well as in the Ural Mountains, and the Donetz Basin of Russia. This sea then retreated, and land conditions prevailed in the greater part of China until uppermost Visean, since even the Lower Choniukou Beds of Kansu [Nan-Shan geosyncline] are continental. A direct connection between China and Tian-shan in Upper Visean times is proved by the occurrence of corals of the Upper Fengninian, *Yuanophyllum* zone in central Tian-shan (Sokolov, 1940).

The Upper Visean, *Productus giganteus* Beds, have been recorded in China in north Kwangsi by Kinlan (1930) in the Liucheng district, in eastern Tsinling, Shensi, north of Sichuan River; in the Nanking Hills, Kiangsu, by Lee (1939); at Schan-tan-tien, south-east of Kan-chow, in Kansu, by Schellwien (1903); from Cho-Niu-Kou and other localities in Kansu by Chao (1927); and on the borders of north-west Kansu on the River Bardoun, a tributary of the Edsin-gol, at about 99° longitude and 39° latitude by Venukoff (1888, 1889). According to Lee (1938), the Upper Visean, *Yuanophyllum* zone of China is found in Kwangsi, Kweichow, Hunan, Anhui, Kiangsu, Kansu, and Sinkiang. The coral fauna of the Lower Yangtse Carboniferous, and also of Lintan higher up this river, are said by Tolmachoff (1931) to be Tournaisian. Continental deposits of Lower Carboniferous age occur in eastern Kansu; south-east and north-east Kiangsi; south Anhui; Chekiang; and Fukien, while no Lower Carboniferous deposits occur in Manchuria; Chihli, Shantung; north Kiangsu; Honan; Shansi; north Shensi; south-west and north Szechuan and Tapashan Range; Hupeh; and south-west Kwangsi. There appears to have been an eastern gulf by way of Anhui and Kiangsu in eastern China, which may have communicated with the north-to-south branch of the sea covering Japan. No Lower Carboniferous occurs in Korea or Manchuria, which probably formed part of the land mass that covered most of northern China and extended across Siberia as Angara Land. There is at present no evidence in support of Grabau's east-to-west strait through Manchuria and Mongolia in Visean times, but it is probable that the Lower Carboniferous beds, with *Productus* cf. *giganteus*, at Sair-Usu and Gurbun Saikhan, 200 miles farther to the east-south-east, in central Mongolia (recorded by Berkey and Morris, 1927) will prove to be Upper Visean, and that these beds were deposited in a gulf extending eastwards from Sinkiang. Most of the Mongolian and Dzungaria deposits are Tournaisian, while no Lower Carboniferous occurs in Alashan and Ordos in Inner Mongolia. From Kiangsu a narrow strait appears to have extended north-westwards by way of the Tsinling-shan geosyncline north of Tapashan Range in Shensi to Kansu.

From the Nan-Shan geosyncline¹ of Kansu, north-west China, the Visean sea,

¹ Visean deposits are recorded by Leuchs (1935) from a number of localities in central Asia which are not marked on the map (pl. xvii) as no fossil lists are quoted and it is uncertain if the *Productus giganteus* Beds are really represented. The sea has been extended to include these localities.

considerably enlarged in width, probably extended north-north-west by way of the Bogdoola Range and Chol-Tau Mountains and the River Yuldus to the Kuldja district. Southwards it spread over the region of Lob-nor and the Tarim desert, by Utsch-turfan and Basch-tschakma, west of Utsch-turfan, on the upper Tauschkandaria River, a tributary of the Tarim in north-western Sinkiang towards Kashgar. Keidel (1906) recorded *P. giganteus* var. *edelburgensis* from Utsch-turfan and Basch-tschakma, and in the Kukurtuk Valley to the north-west near Kashgar. Similar beds were recorded by Yanishevsky (1928) from Lake Son-kul and Narynsk in the Terskei-Alatau and Kok-shal-Tau Mountains, while Tolmachoff (1931) recorded Upper Visean from Lake Issyk-kul in the same region of Russian Turkestan. In south Tian-shan there are said to be two stages of the *Dibunophyllum* zone (Krenkel, 1913), the Lower or Kurumduk Shales with *P. giganteus* var. *edelburgensis*, and the Upper or Safarbai Shales. Lower Carboniferous beds probably including Tournaisian, Lower? as well as Upper Visean beds, are recorded by this author from a number of mountain ranges in Tian-shan, such as the Temurlyk-Tau, Barlyk Mountains, etc. In Tian-shan and Turkestan the Visean deposits are extensive and of considerable thickness, and the Visean sea appears to have enlarged to a broad sea.

Two facies of the Visean occur in central Tian-shan, the more northerly, consisting of red arkoses and violet-red limestones, represents a coast deposit of Upper Visean and possible Lower Namurian age, north of which lay Lower Palaeozoic land. These red deposits, containing *Gigantella edelburgensis*, *G. latissima*, etc., and other European forms, as well as corals of the *Yuanophyllum* zone of China, extend as a narrow band from Narynsk towards Lake Son-kul and east to the Khalyk-Tau Range in Sinkiang, being finally replaced by normal marine deposits. The more southerly deposits consist of thick limestones of the extensive Visean sea which overlies Tournaisian and Upper Devonian beds. Continental deposits occur immediately south of and on the northern shores of Lake Balkash.

In Ferghana, to the south-west, Visean beds occur at a number of localities which have been already referred to, and similar beds are found in the Kasy-kourt Range near Tchimbkent to the north-west. From here it may have extended along the region of the Ishim River, Kazakhstan, where both Tournaisian and Visean beds occur with a fauna linking them to boreal forms, especially in the lower beds, and partly to forms of the Urals and Turkestan, and of the Kuznetzk Basin.

In Tournaisian times Grabau's northern strait through Mongolia is said to have been in connection with the Himalayas by way of Lake Balkhash and Semipalatinsk in Siberia. This connection may have persisted in Visean times, and may have linked the Kuznetzk and Tomsk sea with Ferghana. In neither area are the *P. giganteus* beds developed, and it is doubtful if beds higher than D_1 are represented at Tomsk. The sea retreated from Kuznetzk at the end of the Tournaisian, and Tolmachoff suggested (1926) that only Lower Visean beds are present, the upper zones being mainly represented by continental or marsh deposits. In the Krasnoyarsk region about 200 miles west of Tomsk, marine fossiliferous beds are lacking and the Lower Carboniferous, according to Bazhenov (1938) is represented by brightly coloured marls and conglomerates, and by sandstones with *Lepidodendron*, probably continental or coastal deposits.

So far no Visean has been recorded from the Darvas or from Bokhara, or from the Kirghiz Steppe, except in the west; the sea must, however, have extended across part of Khorasan, and by way of the Elburz Mountains in North Iran to Armenia. Here both Tournaisian and Visean are developed in the gorge of the Araxes River, at the mouth of the Arpatchai Valley, and west of Djoulfa on the Persian side of the Araxes. One arm of the sea may now have extended into Asia Minor, where Visean has been recognized both in the Taurus Mountains, and along the shores of the Black Sea. This arm may have

continued via the Balkans by Yugoslavia, west Serbia, and Bosnia to north Hungary and the Carnic Alps, and so westwards to Great Britain, while a second arm of the Tethys may have extended from Iran across North Africa to Oran and Morocco. The Carboniferous beds of Syria and Mesopotamia are, however, said to be Tournaisian by Tolmachoff (1931).

The Ural and Nova Zemlya geosyncline formed a second link with the Arctic. It united with the Turkestan sea of central Asia by a strait, east of the Aral Sea, by way of the Ishim River and Dzezkazgan, and was also connected at times with the Lower Carboniferous sea of the remainder of Russia. The Ural geosyncline may also have had a direct connection with the Tethys by way of the Caspian Sea. Part of the Ural Visean is, however, continental. A third link with the Arctic by the Verkhoyansk geosyncline in Siberia was suggested by Tolmachoff (1926, 1931) along the upper course of the River Lena, but the fauna may be Tournaisian and ?Moscovian, and there is no evidence for its existence in the Visean.

Tolmachoff (1931), who discussed the palaeogeography of the Tournaisian, referred to the Ural and west Siberian sea, extending north to south, as the Ryphei. This sea united with the Tethys which extends from east to west, near the Caspian and Aral Seas, which are said to be remnants of the Ryphei. In the Tournaisian Tolmachoff stated that the Tethys predominated and extended across central Siberia while the Ryphei is much reduced into gulfs and straits with many islands. In the Visean the Tethys is said to be much reduced in the eastern part while the Ryphei predominated, having invaded much of European Russia, Novaya Zemlya, and the Arctic, but it no longer extended across Siberia.

There were therefore four, or possibly five, land masses in Asia during Upper Visean times: (1) Gondwanaland with Peninsular India, Afghanistan, southern Iran, and Arabia, and extending south of Sumatra to Australia; (2) Cathaysia, covering a large part of east China, and possibly the Philippine Islands and the East Indies islands; (3) Tibet (Tibetia of Grabau, 1924), which may have been united to Gondwanaland; (4) southern Mongolia, probably united with Korea and Manchuria and referred to as Gobia by Grabau (1924). This was probably united to the Siberian land mass of Angara except at its western end. (5) Angara, covering most of Siberia east of the Ural geosyncline.

Owing to the fact that large areas of Asia are practically unexplored geologically, and that the older surveys only mapped younger Palaeozoic or Permo-Carboniferous beds, the lines on pl. xvii can only be approximately correct. In some regions where no Carboniferous is present erosion may have occurred prior to the deposition of the Permian, and folding, faulting, and thrusting render the piecing together of Lower Carboniferous history an exceedingly complicated problem.¹

¹ The probable distribution of land-areas in Asia in Lower Carboniferous times is discussed by W. N. Edwards in Appendix IX, p. 78.

VII. SYSTEMATIC DESCRIPTIONS OF BRACHIOPODA

(Pls. I-X)

(1) Lower Carboniferous of Bukit Charas, Bukit Sagu, and Bukit Tinggik

Order PROTREMATA

Superfamily DALMANELLACEA

Family SCHIZOPHORIIDAE

GENUS *SCHIZOPHORIA* King, 1850

GENOTYPE *Conchylolithus Anomites resupinatus* Martin

Schizophoria mesoloba (Yanishevsky)

(Pl. iv, figs. 4 a, b)

1900. *Orthis mesolobus* Yanishevsky, p. 107, pl. ii, figs. 15 a, b.

1918. *Schizophoria mesoloba* (Yan.) Yanishevsky, p. 20, pl. i, fig. 11.

This species is represented by six specimens, three of which are young forms. All the specimens are much decorticated and poorly preserved, and only two have the two valves still united. The most complete specimen [BB. 7832] is 26 mm. long, 31 mm. wide, and 18.5 mm. thick, with hinge 26 mm. long. The brachial valve is convex with a shallow median sulcus, while the pedicle valve is slightly convex, flattening anteriorly. The anterior commissure is incipiently episulcate. The shell is quadrate in outline with greatest width about midway between posterior and anterior extremities and the cardinal area is less than the greatest width of the shell. The ventral umbo is not preserved, but the dorsal umbo is gibbous. The shell is ornamented by very fine capillae (about 65 in 10 mm. or 6 to 7 in 1 mm. at distance of 1 cm. from umbo), which increase slightly in width anteriorly and increase in number by means of numerous bifurcations and intercalations. Spine-bases are rarely preserved and are scattered over the shell and cause slight enlargement of the costae from which they spring. The spines extended tangentially to the surface. Punctae are visible on some parts of the shell.

In specimen BB. 7832 the fractured ventral umbo exposed subparallel dental lamellae situated about 4 mm. apart and the low euseptoidum between them. The brachioophore plates could be seen diverging from the umbo at an angle of 100° in one small specimen [BB. 7837].

MATERIAL AND LOCALITY.—Six specimens. Five from Bukit Sagu [BB. 7832-6] and one from Bukit Tinggik, Pahang [BB. 7837].

REMARKS.—*Schizophoria mesoloba* was described originally by Yanishevsky (1900) from the Visean, C1 (e), of Schartymka River, eastern Urals, and was also figured in 1918 from the Visean of Ferghana, Russian Turkestan. Both these descriptions are unfortunately only given in Russian. The original figures show the type to be very finely costate with thirty-five or more costae in 10 mm. The sinus commences about 12 mm. from the umbo in the brachial valve. In the pedicle valve there is a low median fold about 4 mm. wide, demarcated by two lateral sulci. Spine-bases cannot be seen in the figure and must

have been fine if developed, as they do not cause any enlargement of the costae. The dimensions of the figured specimen appear to be 30 mm. long and 35 mm. wide, while a thickness of 17 mm. is quoted by Yanishevsky. The Ferghana specimen figured by Yanishevsky in 1918, consisting of a brachial valve with well-developed median sinus, is approximately 25 mm. long and about 30 mm. wide with an exceedingly fine ornament resembling that of the Malayan specimens. The figure is poorly reproduced; spine-bases could not be distinguished and none of the costae appears to be enlarged.

The British Lower Carboniferous species of *Schizophoria* have recently been described by Bond (1942), who separates them into: (A) "Group with coarse ornament" with three or more costae in 1 mm. at 1 cm. from ventral umbo, spine-bases scattered over shell, and widely divergent dental lamellae, e.g. *S. resupinata* (Martin) and vars. *S. hudsoni* George, and *S. nuda* George and Ponsford, *S. connivens* (Phillips); and (B) "Group with fine type of ornament," with six, eight, or nine to ten costae in 1 mm. at 1 cm. from ventral umbo, no spine-bases are developed, but every tenth to fifteenth costa may be enlarged in the pedicle valve, e.g. *S. gibbera* (Portlock), *S. palliata* Demanet, *S. woodi* Bond. The dental lamellae are said to diverge at a lower angle than in Group A, and the species are considerably more inflated.

Careful examination of Group B forms has shown, however, that fine spines are developed, though more often on the posterior part of the shell. The enlarged costae which occur in this group may also bear spines anteriorly.

Comparison of the Malayan forms of *S. mesoloba* with the British species shows that they do not belong either to Group A or B, but that they have the fine costation of Group B, and spine-bases as in Group A. The dental lamellae also diverge at a higher angle than in Group B forms, but the outline of the shell and anterior commissure are comparable to those of *S. connivens* (Phillips), as represented in Bond's text-figure 35, top figure, which shows incipient biplication. Though not actually stated in the paper, this specimen is represented twice its natural size, and its dimensions are, therefore, half those of *S. mesoloba*: The ornament in the Malayan specimens is considerably finer, there being three to four costae in 1 mm. in *S. connivens*, from Bolland, Yorkshire, and six to seven in 1 mm. in *S. mesoloba* from Malaya. The incipient biplication of the anterior commissure also resembles that of the small form figured by Demanet (1934) as *Schizophoria resupinata* var. *dorsosinuata* from the Upper Tournaisian (C₁ subzone) of Belgium, and probably from the Viséan of England (George and Ponsford, 1938, p. 229). In this variety a dorsal median sinus is well developed but the valves are very slightly convex, and the ornament is coarser (three to four costae in 1 mm. at distance of 1 cm. from umbo).

Schizophoria sp.

A single imperfectly preserved brachial valve from Bukit Sagu [BB. 7820] differed from the specimens of *S. mesoloba* in having no median sinus, in its more elongate-oval shell outline, and in its slightly coarser costae. The shell is inflated umbonally, but decreases slightly in convexity in later growth-stages. Its dimensions are: length 32.5 mm.; width 42 mm.; thickness 8 mm. The umbo is massive and suberect. The cardinal area is not preserved.

The shell is ornamented by fine costae, about fifty in 10 mm., in the middle of the valve, or four to five in 1 mm. at a distance of 1 cm. from the umbo. Some of these are slightly enlarged above the fine spine-bases which appear to be scattered over the shell. There do not appear to be two series of costae as in some European species.

REMARKS.—This specimen differs from typical British specimens of *Schizophoria resupinata* in its finer costation and lack of median sinus.

In shell outline it resembles two specimens figured by Yanishevsky (1918, p. 19, pl. iv,

figs. 2 *a*, *b*, pl. vi, figs. 16 *a*, *b*) from Ferghana as *Schizophoria resupinata*. These specimens are laterally elongated without a median sinus in the brachial valve, which is inflated as in the Malayan form. The costation is extremely fine and uniform in size, but owing to the poor reproduction of the plates it is difficult to count the number per centimetre.

Schizophoria resupinata has been recorded frequently from the Visean of Asia, for example, by Krenkel (1913, p. 12) from Chodschur-noe-ussun, and from Basch-sugun, north-east of Kashgar in the Kurumduk Valley, Tian-shan.

It has been recorded from both Tournaisian and Visean of the Kuznetzk coal-field, Altai, west Siberia, by Tolmachoff (1926).

Superfamily PENTAMERACEA

Family CAMEROPHORIIDAE

GENUS *STENOSCISMA* Conrad, 1839¹

GENOTYPE *Terebratulites schlotheimi* Von Buch

- 1839. *Stenoscisma* Conrad, p. 59.
- 1844. *Camerophoria* King, p. 313 (nom. nud.).
- 1846. *Camerophoria* King, p. 89.
- 1846. *Camarophoria* (emend. pro *Camerophoria*) Herrmannsen, p. 161.
- 1877. *Stenoscisma* Conrad: Dall, p. 65.
- 1887. *Stenoschisma* Conrad: Oehlert, p. 1309.
- 1897. *Stenochisma* Conrad: Schuchert, p. 413.
- 1942. *Stenoscisma* Conrad: Cooper, p. 229.

non *Stenochisma* Hall, 1848 and 1867.

***Stenoscisma saguensis* sp. nov.**

(Pl. ix, figs. 5 *a-c*, 6 *a*, *b*)

DIAGNOSIS.—*Stenoscisma* about 29 mm. long, 34 mm. wide, and 22 mm. thick; subpentagonal in outline, brachial valve globose, medianly arched, but without true median fold, pedicle valve with broad median sinus anteriorly, linguiform extension about 18 mm. in length, subtruncate; shell surface without plications. Apical angle 105°.

TYPE-SPECIMEN.—Holotype preserved in the British Museum (Natural History) [BB. 7827] from the Visean of Bukit Sagu, Pahang. Paratype from Bukit Tinggik [BB. 7828].

MATERIAL AND LOCALITY.—Five specimens, four of which are fragmentary [BB. 7827 and 7829] from Bukit Sagu, [BB. 7828, 7830-1] from Bukit Tinggik, Pahang.

DIMENSIONS.—Holotype. Maximum length, 29.1 mm.; maximum width, 34.4 mm.; maximum thickness, 22.1 mm.

DESCRIPTION.—Both valves are convex in the neanic stage, and the shell is circular in outline. The pedicle valve is medianly depressed at a distance of about 12 mm. from the umbo, and a shallow sinus, broadening and deepening in later growth-stages, is then developed. The lateral slopes are only slightly convex. The anterior part of the valve is produced dorsally into a tongue-like, linguiform extension, which is parallel-sided and dorsally subtruncate. The lateral commissure slopes ventrally from the umbonal slopes at an angle of about 30° to the vertical. The dorsal valve becomes increasingly convex,

¹ The name *Stenoscisma* proposed by Conrad in 1839 with type *Terebratulites schlotheimi* Von Buch, has been revived by G. A. Cooper (1942), and substituted for *Camerophoria* King 1844.

and arches up to the ill-defined median fold, and the shell in the ephebic stage assumes a subpentagonal outline.

The umbo is imperfectly preserved, but probably tapered to an acute extremity which is incurved and in contact with the brachial valve. The shell in one brachial valve was 2.5 mm. thick. No plications are developed on median fold and sinus, or on the flanks in any of the specimens. Growth-lines are obscure.

In the pedicle valve a median septum 12 mm. in length can be seen through the test. In specimen No. **BB. 7828** this septum is seen in contact with the spondylium, and extending for a distance of about 1 mm. anterior to it. A median septum is developed in the brachial valve, but details about the hinge-plate, camarophorium, etc., could not be ascertained owing to lack of material. One decorticated fragment, preserved as an internal cast of the brachial valve, showed faint adductor impressions. These formed an elongate-oval muscular area extending from 1 mm. below the umbo for about 15 mm.

REMARKS.—*Stenosisma* [= *Camerophoria*] *saguensis* is readily distinguished from other Carboniferous species by its large dimensions, globose brachial valve, and lack of costation. In shell outline and ornament it resembles specimens frequently associated with typical *S. [Camerophoria] rhomboidea* (Phill.) from the British Visean, D₂ subzone. These specimens are smooth, have a similar globose brachial valve and low median fold, but adult shells do not attain greater dimensions than a length of 10 mm., width 12 mm., and thickness 9 mm. Two similar forms of small size are figured by Yanishevsky (1918, p. 64, pl. vii, figs. 19 *a*, *b*, and 35) as *Camerophoria rhomboidea*, and *C. verneuiliana* Grunewaldt from the Visean of Ferghana, Russian Turkestan.

C. donica figured by Rotai (1931, p. 129, pl. v, figs. 1–4) from the Lower Carboniferous, Visean, Beschevo Limestone, of the Donetz Basin, Russia, is similar in shell outline and contour, but is also about one-third of the size of *Stenosisma saguensis*. These Donetz specimens are from the suggested equivalent of the D₃ subzone of Great Britain.

S. saguensis differs from *Camerophoria rhomboidea* var. *arctica* Semichatova (1935) from the Lower Carboniferous, Visean, of Novaya Zemlya by its larger dimensions, less pentagonal outline, and more globose shell. A single plication may be developed on the median fold and sinus in the Nova Zemlyan shells.

No comparable specimens have been figured from the Lower Carboniferous of Asia. Specimens of smaller size but comparable in outline were figured by Merla (1934, pl. xxiii, figs. 3, 19) from the Uralian, *Schwagerina* zone, of Rimu, Caracorum, Kashmir.

Superfamily STROPHOMENACEA

Family PRODUCTIDAE

GENUS AVONIA I. Thomas, 1914

GENOTYPE *Productus youngianus* Davidson

Avonia cf. **davidsoni** (Jarosz)

(Pl. v, fig. 12)

cf. *Productus aculeatus* (Martin): de Koninck, 1847, p. 144, pl. xvi, figs. 6 *a*–*c*.

cf. *Productus aculeatus* (Martin): Davidson, 1861, p. 166, pl. xxxiii, figs. 19, 19 *a*.

cf. *Productus youngianus* var. *davidsoni* Jarosz, 1917, p. 88, pl. x, figs. 12, 12 *a*.

cf. *Avonia davidsoni* (Jarosz): Muir-Wood, 1928, p. 36.

One pedicle valve from Bukit Sagu [**BB. 7839**] with imperfectly preserved ornament resembles *Avonia davidsoni* (Jarosz) from the British, Belgian, and Polish Visean. The

shell is elongate-oval in outline, about 22 mm. long, 22 mm. wide, and 14 mm. thick. The umbo is incurved over the hinge, which is slightly less than the greatest width of the shell. The ears are small and flattened and separated from the umbonal slopes by a shallow sulcus. The shell expands in width rapidly forward from the umbo. No sinus is developed, but the steep flanks curve up on to the broad venter. The posterior part of the shell is ornamented by large rounded spine-bases arranged concentrically. These spine-bases tend to become elongated anteriorly and true costation is finally developed.

REMARKS.—This specimen resembles British examples in dimensions, shell outline, etc., but appears to have the costation less well developed. In *A. davidsoni* costae are traceable over three-quarters of the shell and concentric rows of spine-bases are restricted to the umbonal slopes. The ornament and dimensions of the shell are similar to those of *Productus* [*Avonia*] *karpinskianus* Yanishevsky (1900, p. 129, pl. i, figs. 1, 2) from the Lower Carboniferous, Visean, C1 (e) near the River Scharzymka on the eastern side of the Ural Mountains. The Malayan shell, however, has a slightly more convex visceral disk.

Jaroszyński's specimen from the Visean of a quarry in the Raclawka Valley, near Cracow, Poland, is possibly an immature form, and the dimensions are: *length* 11 mm., and *width* 14.5 mm. The costae appear to be finer than in the average British specimens.

Avonia weberi (Yanishevsky)

(Pl. v, figs. 5, 8)

1918. *Productus* (*Avonia*) *weberi* Yanishevsky, p. 132, pl. viii, figs. 20–23.

A single pedicle valve from Bukit Sagu [BB. 7840] having only the posterior part of the shell preserved, and two pedicle valves from Bukit Charas [BB. 7889, 7899] should probably be identified as *Avonia weberi*, described from the Visean of Ferghana, Russian Turkestan. The shell is 8 mm. long (broken), and 15 mm. wide, with the hinge forming the widest part of the shell. The pedicle valve is convex with small ears separated from the visceral disk by a shallow sulcus. No median sinus is developed, and the flanks slope steeply up to the venter. The umbo is much incurved, and probably projected beyond the hinge.

The ornament consists of numerous fine, rounded spine-bases which anteriorly become more elongated, and are set on low rounded costae, six of which occur in 5 mm.

REMARKS.—These imperfect fragments resemble the figures given by Yanishevsky both in size, contour, and ornament. In the Ferghana specimens six costae can be counted in the space of 5 mm., as in the Malayan specimens.

GENUS BUXTONIA I. Thomas, 1914

GENOTYPE *Productus scabriculus* (Martin)

Buxtonia sp.

(Pl. iv, figs. 3 a, b; pl. v, figs. 11 a, b)

Three imperfect specimens belong possibly to two different species of *Buxtonia*.

The more complete specimen from Bukit Sagu [BB. 7850], pl. iv, figs. 3 a, b, consists of a pedicle valve from which the umbo and one flank are missing. The shell is quadrate in outline, longer than wide with much incurved umbonal slopes. The hinge is slightly less than the greatest width of the shell. The flanks are steep and arch up on to the broad

flattened venter. No median sinus is developed. The ears are small, and not sharply demarcated from the umbonal slopes. The lateral contour forms a fairly regular curve, and no marked geniculation separates the visceral disk from the trail. The ornament consists of fine regular costae (about ten in 10 mm. at 20 mm. below the umbo) which become enlarged above the scattered spine-bases. Bifurcations and intercalations occur rarely. The posteriorly placed spines extended at right angles to the shell surface. About half-way down the shell length the normal ornament is interrupted by a spinose band about 2 mm. in width. The normal costate type of ornament is again resumed for about 5 mm., and a second flattened band bearing small spine-bases is then developed a short distance above the anterior margin. Owing to decortication of the shell, the details of the arrangement of these spines are obscure. About ten concentric ribs were seen on ears and cardinal slopes, flattening on the venter and often bifurcating on the lateral slopes of the visceral disk.

The second specimen, also from Bukit Sagu [BB. 7849], is a fragment of a pedicle valve with similar ornament.

The third specimen, from Bukit Tinggik [BB. 7851], pl. v, figs. 11 *a, b*, consists of the visceral disk of a small slightly deformed pedicle valve which tapers rapidly to the umbo. The visceral disk is convex and well demarcated from the small flattened ears. The hinge is approximately equal to the greatest width of the shell. The flanks slope up gently on to the rounded non-sinuate venter. The costae are slightly coarser than in specimen No. BB. 7850, eight to nine costae occurring in 10 mm., and spine-bases are more prominent. No spinose bands are developed in this specimen.

DIMENSIONS.—Specimen No. BB. 7850: length, 30 mm.; width, 34 mm.; thickness, 23 mm.

REMARKS.—The Malayan specimens are readily distinguished from *B. scabricula* (Martin) from the British Visean by their smaller dimensions, steeper flanks, absence of a median sinus, finer costation, and by the development of spinose bands at an earlier growth-stage. No British form was found to be comparable with the Malayan specimens. A specimen belonging to an unnamed species from the Visean, D₂ subzone, of Llangollen, North Wales B. 23762, has similar steep flanks and non-sinuate venter, but the costae are finer and more numerous, and the width and thickness of the shell are almost equal. A spinose band is also developed in the ephebic stage in this specimen.

Buxtonia scabricula was recorded by Yanishevsky (1918, p. 57) from the Visean of Ferghana, but no figure was given and the description is only in Russian. It was also recorded by Krenkel (1913, pp. 19, 24) from the Visean (=D₂ subzone) of southern and eastern Tian-shan, and especially from Basch-sugun, north-east of Kashgar.

The specimen described by Reed (1927, p. 48, pl. ix, fig. 8) as *Productus scabriculus* var. *impersonata* from the Lower Carboniferous of Ta-shih-wo, Yunnan, does not belong to either this genus or species and should be referred to the genus *Pustula*. Similarly, the specimen figured by Frech (1916, p. 240, pl. vi, figs. 2 *a, b*) as *Buxtonia scabricula* from the Tournaisian of Yerkopru, Taurus, should be assigned to the genus *Pustula*. *Buxtonia scabricula* is listed from the Visean of north Iran by Clapp (1940, p. 34), whence it was recorded by Rivière (1934) from the north of Rudahan. *Productus* cf. *scabriculus* was recorded by Middlemiss (1910) from the [?Tournaisian] *Syringothyris* Limestone, of Kashmir, India.

Neither of the specimens figured by Chao (1927, pl. viii, figs. 1-3) as *Buxtonia scabricula* (Martin) from the Visean, Choniukou formation of Kansu exhibits any spinose bands.

Buxtonia sp. from Malaya differs from specimens of *Juresania juresanensis* (Tschernyschew) from the Uralian by its costate instead of spinose ornament on the posterior part

of the shell. In *Juresania* concentric spinose bands are developed in later growth-stages, as in *Buxtonia*.

Productus scabriculus is figured by Diener (1903, p. 141, pl. vii, figs. 15-17) from the ?Upper Carboniferous, *Fenestella* Beds of Losar Nullah, Spiti. He suggested that the varietal name, var. *spitiensis*, might be applied to these forms. They agree fairly well in dimensions with the Malayan specimens, but are broader anteriorly with less steep flanks and no sign of anterior spinose bands, seen in the Malayan forms. One interior of the brachial valve shows the bifid septum supporting the cardinal process, characteristic of *Buxtonia*. This character is said not to occur in *P. humboldti* [= *Waagenoconcha*].

The specimen figured as *Productus pustulosus* by Mansuy (1913b, pl. ii, fig. 2) from the Calcaires à *Productus* (?Uralian) of Ban-Sao-Tai, Laos, Indo-China, is a species of *Buxtonia* having five concentric spinose bands replacing the normal costation on the trail, as in the Malayan specimen.

GENUS DICTYOCLOSTUS Muir-Wood, 1929

GENOTYPE *Anomites semireticulatus* Martin

Dictyoclostus sp.

(Pl. v, fig. 2)

Three fragmentary *Productids* from Bukit Sagu [BB. 7853-5], one from Bukit Tinggik [BB. 7852], and one from Bukit Charas [BB. 7886] belong to the genus *Dictyoclostus*, but are too poorly preserved for specific determination.

They resemble small specimens figured by Yanishevsky (1918, pl. v, figs. 2, 3, 7, 9) as *Productus semireticulatus* and *P. concinnus* from the Visean of Ferghana, Russian Turkestan. Only the visceral disk is preserved in the Malayan specimens, and this is slightly wider than long, moderately convex and geniculated to form the trail. A shallow sinus is developed in each specimen about 10 mm. from the umbo. The ears are large and flattened and separated from the umbo by a shallow sulcus. The umbo is not massive and is slightly incurved. The ornament consists of fine, even costae, about twelve in 10 mm., and about fourteen to sixteen narrow concentric ribs. These are continuous round the front of the visceral disk and cause only slight reticulation at the point of intersection with the costae. A row of spine-bases is set at a low angle to the hinge, and small spine-bases are also scattered over the visceral disk.

The largest and most complete of these specimens [BB. 7854] measured 30 mm. in length, 30 mm. in width, and 25 mm. in thickness.

Dictyoclostus cf. *deruptus* (Romanowsky)

(Pl. iv, figs. 6 a, b)

cf. *Productus deruptus* Romanowsky, 1880, p. 120, pl. xix, figs. 2 c-f, and 3; pl. xx, figs. 1, 2 a-c.
cf. *Productus deruptus* Romanowsky: Nalivkin, 1937, p. 65, pl. viii, figs. 1, 2.

A single imperfect pedicle valve of a *Dictyoclostus* from Bukit Tinggik [BB. 7878] resembles the figures of Romanowsky's species *D. deruptus* from the Carboniferous Limestone of south-east of the Kara-Tau Range, on the River Kosch-Karat, Turkestan. The specimen has a highly convex visceral disk which is geniculated to form a curved trail. The umbo is missing, but was probably much incurved as in Romanowsky's species. The

flanks are steep, and arch up to a flattened venter with narrow and shallow sinus anteriorly. The hinge is not preserved. The ornament consists of fine costae, about thirteen in 10 mm., which frequently bifurcate on the flanks, but are fairly regularly developed on the venter. Spine-bases are numerous, and are scattered over the trail with a somewhat quincuncial arrangement, similar to that of *Productus deruptus*. These spines do not cause any thickening of the costae posterior to the spine-bases, but a single costa may bifurcate anterior to a spine-base. The arrangement of the spines on the flanks is obscure, possibly a group of spines of similar diameter may be developed. There does not appear to be any ridge with row of spines of larger size as in the *Dictyoclostus antiquatus* group. Rounded plications of low elevation are seen on the lateral slopes and appear to be faintly traceable across the front of visceral disk without causing marked reticulation at the point of contact with the costae.

REMARKS.—This specimen differs from *D. hindi*, and its variety *wettonensis* Muir-Wood, from the Visean of England, by its finer costation and apparent lack of a prominent ridge bearing spine-bases on the flanks. The spines on the trail also appear to be more numerous than in the English species, and longitudinal ridges bearing two or more costae are not developed below the spine-bases. Although the specimen is fragmentary the ornament, general shape and dimensions agree well with that of Romanowsky's species. *D. deruptus* has been recorded from the Lower Visean, Ishim Beds, of north-east Kazakhstan by Nalivkin (1937), from the Tournaisian, C₁ of Talassic Alatau Range of Tian-shan by Sergunkova (1935), and from the Kara-Tau Range, Turkestan, by Weber (1935) from either Tournaisian or Visean.

A similar form was figured by Hayasaka (1924, p. 26, pl. v, figs. 1, 2) as *P. cf. semi-reticulatus* from the Lower Carboniferous, Visean, of Omi-mura, Echigo, west Japan. The trail of the Japanese specimen is slightly longer than in the Malayan specimen, but the ornament is similar, the sinus pronounced, and the flanks steep.

GENUS ECHINOCONCHUS Weller, 1914

GENOTYPE *Anomites punctatus* Martin

Echinoconchus sp.

(Pl. v, fig. 9; pl. ix, fig. 7)

This genus is only represented by one imperfect pedicle valve [BB. 7847], and a fragment of the same valve from Bukit Tinggik, both having the characteristic ornament of flattened concentric bands bearing rows of small spine-bases. The umbo is gibbous, tapering rapidly to an acute extremity, and much incurved. The ears are flattened, and separated from the umbonal slopes by a shallow sulcus and imperfectly preserved, so that the hinge appears to be considerably less than the greatest width of the shell. The shell expands in width rapidly forward from the umbo and is less convex in later growth-stages. The ornament consists of about ten concentric bands (three in 8 mm.) with a single row of larger spine-bases irregularly arranged about the middle of each band, while two or three rows of smaller spine-bases are developed on the anterior part of each band. Internal characters are unknown. The dimensions of the more complete specimen are: *length*, 16.5 mm.; *width*, 19 mm. (approx.); and *thickness*, 9 mm.

REMARKS.—This specimen resembles *Pustula* [= *Echinoconchus*] *venusta* I. Thomas from the British Visean, D₂ subzone, in ornament and dimensions, but the shell tapers more rapidly to the umbo than is usual in this British species. Nalivkin (1937, p. 62, pl. x,

figs. 11-15) figured *Productus* aff. *subelegans* I. Thomas from the Visean, Yagovkin Beds of north-east Kazakhstan, Turkestan. This specimen has similar ornament to the Malayan form, but has a broader and less tapering shell with narrower concentric bands.

GENUS GIGANTELLA Sarytcheva, 1928

GENOTYPE *Anomites giganteus* Martin

Gigantella cf. **latissima** (J. Sowerby)

(Pl. iv, fig. 5)

cf. *Productus latissimus* J. Sowerby, 1822, pl. cccxxx (upper figure).

cf. *Productus latissimus* Sowerby: Yanishevsky, 1918, p. 27, pl. ii, fig. 2 (only).

A small immature brachial valve from Bukit Tinggik [BB. 7881], in which the width is about three times as great as the length, belongs to the *Gigantella latissima* group. The shell is 14 mm. long and approximately 33 mm. wide, and tapers rapidly laterally. The cardinal extremities and hinge are not preserved. The pedicle valve and inner layers of the brachial valve have split off leaving a lower layer (reverse of the exterior) of the brachial valve exposed. The shell is ornamented by costae radiating out from the umbonal slopes with rare bifurcations. There are ten costae in 10 mm. at 11 mm. from the umbo. Spine-bases were not observed and were probably not numerous on the brachial valve. No concentric ribs are developed.

REMARKS.—It is somewhat remarkable that this should have been the only specimen of *Gigantella* obtained, and it seems probable that other *Gigantellas* may have occurred, but have been too much veined by calcite to be collected. This specimen is not a typical *G. latissima*, but is nearer to forms commonly referred to as "latissimoid *Productids*" from the British Visean. The costae are broader, more even and regular in width than in *G. latissima*. Growth-lines are not conspicuous, and spines less numerous.

It is possible that the Malayan specimen is a young form of *Productus latissimus* figured by Yanishevsky (1918, pl. ii, fig. 2) from the Visean of Ferghana, Russian Turkestan. This specimen is laterally elongate and rather similarly costate in its dimensions and resembles *Gigantella latissima* (Sow.).

Sergunkova (1935, p. 9, pl. i, figs. 1-3) figured several specimens as *Gigantella* aff. *latissima* from the Visean, D₁ subzone of the Talassic Alatau Range, Tian-shan. These specimens are not only larger than the Malayan form, but appear to have larger ears and more irregularly developed costae. *Gigantella latissima* was also recorded but not figured from the Visean of Tian-shan by Gröber (1909, p. 373).

GENUS KROTOVIA Fredericks, 1928

GENOTYPE *Productus spinulosus* J. Sowerby

Krotovia **multituberculata** (Yanishevsky)

(Pl. v, figs. 4, 10)

1918. *Productus (Avonia) multituberculatus* Yanishevsky, p. 132, pl. viii, figs. 25-30, 33, 34.

Four small fragmentary pedicle valves are referred to the genus *Krotovia* on account of their ornament of spine-bases which are not arranged on concentric bands or ribs. The shell is very convex, without median sinus, and the flanks slope gently up to the

arched venter. The visceral disk is separated from the wide flattened ears by a shallow sulcus. The umbo is incurved, but the hinge and brachial valve are not preserved. The spine-bases are rounded or elongated, and of small size and closely spaced without any definite arrangement, while the spines probably extended at right angles to the shell surface.

The dimensions of the four specimens are very similar. In specimen No. **BB. 7882** the length is 8.5 mm. and the width 10 mm., while the hinge appears to be slightly less than the greatest width of the shell. The thickness of the pedicle valve is 2 mm.

MATERIAL AND LOCALITY.—Two specimens from Bukit Sagu, Pahang [**BB. 7882-3**], and two from Bukit Charas [**BB. 7896-7**].

REMARKS.—These four small specimens are probably immature forms of *K. multituberculata* (Yanishevsky) from the Visean of Ferghana, Russian Turkestan. Yanishevsky describes this species as having a shell of small size, with a very convex pedicle valve and concave dorsal valve. The hinge is said to form the widest part of the shell and the umbo is much incurved. No sinus is developed, and the flanks are steep. Small ears are developed. The ornament consists of numerous elongated minute spines arranged in checker-board fashion. One of the Ferghana specimens is said to measure 17 mm. in length and 18 mm. in width, and to differ from *K. spinulosa* (Phill.) in its more protuberant beak and more elongated tubercles.

Some of the smaller specimens figured by Yanishevsky resemble the two Malayan specimens and the ornament is similar. The spine-bases are more numerous and of smaller size and more elongated than in *K. spinulosa* from the British Visean.

The arrangement of the spines in this species suggests that it belongs to *Krotovia* rather than to *Avonia*. Elongation of the spine-bases without the actual formation of costae occurs commonly in species of *Krotovia*.

Krotovia cf. *keyserlingiana* (de Koninck)

(Pl. v, figs. 1 a, b)

cf. *Productus aculeatus* (Martin): de Koninck, 1843, p. 200, pl. x, figs. 8 a-c.

cf. *Productus keyserlingianus* de Koninck, 1847, p. 134, pl. xiv, figs. 6 a-d.

cf. *Productus keyserlingianus* de Kon.: Davidson, 1861, p. 174, pl. xxxiv, figs. 15, 16.

1924. *Productus* cf. *aculeatus* (Martin): Hayasaka, p. 33, pl. v, figs. 10, 11.

This specimen from Bukit Tinggik [**BB. 7856**] resembles de Koninck's species in its small dimensions, quadrate outline, convex pedicle valve, and slightly concave brachial valve. The ears are small and not sharply demarcated from the visceral disk, and the flanks slope up to the slightly flattened venter. The apex of the ventral umbo is not preserved, but it was probably acute and incurved. The hinge is slightly shorter than the greatest width of the shell. The ornament consists of rounded and rather prominent spine-bases arranged more or less quincuncially with a slight tendency to concentric rows on the visceral disk, but more scattered on the trail. The ornament of the pedicle valve is reproduced in reverse on the brachial valve, but spine-bases were not observed on this valve. Growth-lines are prominent on both valves. The shell is 10.5 mm. long, 12.5 mm. wide, and 6 mm. thick. Faintly demarcated concentric ribs occur on the cardinal slopes.

REMARKS.—*Krotovia keyserlingiana* occurs in the Visean of Belgium, and in the D₂ subzone of Derbyshire and Yorkshire. It is readily distinguished from *K. spinulosa* by its quadrate shell outline, broad flattened venter, smaller and less flattened ears, and by the less convex brachial valve and consequent larger body cavity. The ornament in the two species is also different.

P. keyserlingianus was described, but not figured, by Yanishevsky (1900, p. 133) from

the Lower Carboniferous, Viséan, of the eastern Urals near the Schartymka River, south of Miask.

The Malayan example resembles Hayasaka's specimen of *Productus* cf. *aculeatus* (1924, p. 33, pl. v, figs. 10, 11) from the Lower Carboniferous, Viséan, of Omi-mura, Echigo, west Japan, in dimensions, shell contour, and ornament. The concentric ribs are, however, better defined in the Japanese specimen. Yanishevsky's specimen of *Pustula semiglobosa* (1918, p. 52, pl. ii, figs. 10 a, b) resembles the Malayan form in shell outline, but is slightly smaller and the spines appear to be less prominent.

GENUS LINOPRODUCTUS Chao, 1927

GENOTYPE *Productus cora* d'Orbigny

***Linoproductus yunnanensis* (Loczy)**

(Pl. iii, figs. 5 a, b)

- 1890. *Productus yunnanensis* Loczy, p. 680 (list only).
- 1897. *Productus yunnanensis* Loczy, p. 106, pl. vi, figs. 1, 2, text-fig. 18.
- 1924. *Productus yunnanensis* Loczy: Grabau, p. 245, text-fig. 168.
- 1927. *Productus yunnanensis* Loczy: Reed, p. 42, pl. viii, figs. 8 a-d.
- 1927. *Productus yunnanensis* Loczy var.: Reed, p. 44, pl. ix, figs. 1, 1a, 1b.

The single example of this species [BB. 7857] is unfortunately incomplete, and the hinge and half the visceral disk are not preserved. Sufficient remains, however, to identify it as Loczy's species.

The shell is elongate-oblong in outline, but the visceral disk tapers rapidly to the rather massive umbo. The flanks are almost vertical and slope up steeply to the rounded and non-sinuate venter. The visceral disk is highly convex and is geniculated to form a trail, which is well preserved and is not spreading. Only part of one ear is preserved and this appears to have been flattened, and separated from the visceral disk by a shallow depression. The umbo is much incurved and probably projected beyond the hinge. The shell is fractured and shows the brachial valve in section to be flattened on the visceral disk, and then geniculated to form a trail which is in contact with the trail of the pedicle valve near the anterior margin.

The shell of both valves is moderately thick and in the pedicle valve is ornamented by fine costae, but no concentric ribs were observed. Growth-lines are very numerous and form a well-marked concentric ornament on the better preserved parts of the shell, causing nodular enlargements of the costae. The costae on the visceral disk are rather irregular in width due to numerous intercalations which, however, attain normal width in the space of 5 mm. or less. On this part of the shell the costae radiate out evenly from the umbo. On the trail intercalations are rarely observed and the costae are more irregular; two may converge to form one thickened costa while adjacent costae may decrease in width, and there is a tendency for all the costae to converge towards the median part of the trail. There are fourteen costae in 10 mm. at a distance of 30 mm. from the umbo, and fifteen costae in a similar space on the anterior part of the trail. Spine-bases occur rarely, and only four were observed. These are of small diameter set on the summit of the costae without causing any irregularity in their development. The row of six to seven spine-bases set along the hinge on either side of the umbo in Loczy's and Reed's figures were not preserved. The ornament of the brachial valve is unknown.

DIMENSIONS.—Length, 67 mm.; width, 54 mm.; thickness, 43 mm.

MATERIAL AND LOCALITY.—One specimen [BB. 7857] from Bukit Sagu, Pahang.

REMARKS.—This species was well figured by Loczy from the Permo-Carboniferous of Wo-shih-wo, Yunnan, which Reed states is the same as Ta-shih-wo, Yunnan, where several specimens were collected by Coggin Brown (1916, p. 209). These are similar in size, contour, and ornament to the Malayan form, but the trail in the Malayan specimen is, however, better preserved. The specimen figured as a variety of *P. yunnanensis* resembles the Malayan forms more closely than that figured as *P. yunnanensis*. Reed distinguishes it by its narrower and longer shape and more developed trail and steeper flanks. The ornament is said to be similar to the type, but the costae are more numerous and more regular. As the Malayan specimens appear to have the form of Reed's variety and the ornament of the specimen considered by him to be typical, it is proposed to identify both Reed's specimens as *L. yunnanensis*.

The largest of the specimens figured by Loczy is 64 mm. long, 55 mm. wide, and 30 mm. thick. The irregularity of the costae on the trail is well shown and no spine-bases are depicted except the row along the hinge.

This species differs from *L. corrugatus* (M'Coy) in its less numerous intercalations which more rapidly attain normal width, and in its less numerous spines, which in M'Coy's species are scattered over the shell and occur in a group on the ears and along the cardinal slopes. The absence of large spine-bases on the trail readily distinguishes it from typical specimens of *L. cora* (d'Orb.).

It differs from *Linoproductus kokdscharensis* (Gröber) in its more convex visceral disk which tapers more rapidly to the umbo, in its steeper flanks and longer trail, and in fewer concentric ribs which are only developed on the ears.

Frech (1911, p. 102) recorded *P. yunnanensis* from the Upper Carboniferous of Yunnan-fu, but it is uncertain if his specimens were correctly identified. Deprat (1912) also mentions this species, but it is not figured in any of Mansuy's works on Indo-China and Yunnan. Yabe and Hayasaka (1920, pl. xxvi, fig. 5) figured *P. aff. yunnanensis* from the Upper Carboniferous or Permian of Wei-ning-hsien, Kweichow, south China. According to Ting and Grabau (1934, p. 4) this species occurs in the Chiussuan or Middle Fengninian in southern Kweichow in the districts of Tatang and Tushan, where it occurs in a black shaly limestone. The Chiussuan Series is regarded by Ting (1931) as equivalent to the *Seminula* zone of Great Britain. With the exception of southern Kweichow, the Chiussuan is represented by continental deposits in southern China which might account for the limited distribution of *L. yunnanensis*.

Linoproductus kokdscharensis (Gröber)

(Pl. iii, figs. 2-4)

1908. *Productus cora* d'Orb. var. *kok-dscharensis* Gröber, p. 236, pl. xxviii, figs. 1 *a-c*, 2 *a, b*, 3-5; pl. xxx, fig. 4 (non pl. xxvii, fig. 3).
 1918. *Productus kokdscharensis* Gröber: Yanishevsky, p. 42, pl. ii, figs. 3 *a, b*.
 1927. *Productus* cf. *cora* d'Orb. var. *kok-dscharensis* Gröber: Reed, p. 46, pl. ix, fig. 2.

Only the pedicle valve is preserved in all fifteen examples of this species. The specimens have a moderately convex visceral disk, and gently sloping flanks and short trail. No median sinus is developed and the venter is flattened or rounded. The ears are flattened, large, and are separated from the visceral disk by a shallow sulcus. The hinge forms the widest part of the shell. The umbo is small and slightly incurved, but does not project far beyond the hinge-margin. In lateral contour the shell is semicircularly curved, and a short trail is only preserved in one specimen.

The ornament consists of fine rounded longitudinal costae, concentric rugae, and fine

spine-bases. The costae radiate out fairly evenly from the umbo and increase by means of bifurcations and intercalations. The intercalated costae attain normal width in a distance of about 1 or 2 mm. Bifurcations occur more rarely than intercalations, but may be seen on the flanks and posterior part of the visceral disk. The sulci separating the costae are about half their width. There are about eleven costae in 10 mm. at a distance of 20 mm. from the umbo. They tend to increase slightly in width anteriorly and to become flattened. About eight concentric rugae are developed on the ears and lateral slopes and may be faintly traced round the front of the visceral disk. No enlargement occurs at the point of their intersection of the costae. A group of spine-bases of small size occurs along the cardinal slopes, and spine-bases set on the summit of the costae are fairly numerous on the remainder of the shell.

DIMENSIONS.—Specimen No. **BB. 7867**: length, 35 mm.; width, 50 mm.; thickness, 16 mm. Specimen No. **BB. 7861**: length, 42 mm.; width, 51.5 mm.; thickness, 18 mm.

MATERIAL AND LOCALITY.—Thirteen specimens from the Visean of Bukit Charas (loc. 5048), Pahang [**BB. 7860-70, 7886, 7895**]. Two fragmentary specimens doubtfully identified from Bukit Sagu [**BB. 7858-9**].

REMARKS.—*Linoproductus kokdscharensis* is distinguished from *L. corrugatus* (M'Coy) by its less numerous intercalated costae which more rapidly attain normal width. The visceral disk is less convex, and the trail less extended than in *L. corrugatus*. It resembles it, however, in having a group of fine spine-bases along the hinge and cardinal slopes. *L. kokdscharensis* differs from *L. yunnanensis* in its less convex visceral disk, less steep flanks and shorter trail, also in less prominent growth-lines, more numerous concentric rugae, and in the group of small spine-bases along the cardinal slopes, as well as in differences in the costation.

This species was described and well figured by Gröber (1908) from the Kok-dschar River, Terskei Alatau Range, central Tian-shan, where it occurs in a red limestone associated with *Productus edelburgensis*, *P. striatus*, *P. margaritaceus*, *Lithostroton irregularis*, and *Cyathaxonia dissimilis*, etc.

Yanishevsky (1928, p. 200) gives the sequence of the Visean, east of Ferghana, near Narynsk, central Tian-shan, as consisting of three faunas: (1) with *Productus giganteus* at base, (2) with *Productus edelburgensis* and *P. kokdscharensis*, (3) with *Spirifer bisulcatus*. He states that similar faunas were found by Arghentov near Lake Son-kul in the same region, and also mentions that these faunas of central Tian-shan are identical with those near Tchimkent in the Kasy-kourt Range farther west, where a similar horizon with *P. edelburgensis* occurs.

From these records it seems probable that *L. kokdscharensis* is of Upper Visean age, and probably = D_1 or D_2 subzone. The fauna with "*Spirifer bisulcatus*" [= *Choristites* sp.], mentioned by Yanishevsky, is assigned to the Moscovian on a later page of the same work (pp. 200, 204) [now described as Bashkirian], so that the beds with *Productus edelburgensis* and *P. kokdscharensis* form the top of the Visean. In 1918 Yanishevsky figured a poorly preserved specimen of *P. kokdscharensis* from the Lower Carboniferous, Visean, of Ferghana, which is similar to the Malayan forms. A single example was also figured by Reed (1927) from the Lower Carboniferous of Ta-shih-wo, Yunnan, where *L. yunnanensis* also occurs. *Gigantella* has not been recorded from this locality, and the assemblage of fossils, though suggesting Visean, may not represent the Upper *Dibunophyllum* zone.

All Gröber's specimens are incomplete, but the length is approximately 47 mm., width 47 mm., and thickness 27 mm. At a distance of 20 mm. from the umbo there are from ten to thirteen costae in 10 mm. if the ornament is accurately reproduced. Spines on the visceral disk are said to occur rarely, but this may be due to decortication.

Linoproductus tenuistriatus (de Verneuil)(Pl. iii, figs. 1 *a*, *b*, 2; pl. v, fig. 3)¹

1845. *Productus tenuistriatus* de Verneuil, p. 260, pl. xvi, fig. 6.
1908. *Productus cora* var. *tenuistriatus* de Verneuil: Gröber, p. 220, pl. xxv, figs. 1 *a*, *b*.
1918. *Productus tenuistriatus* de Verneuil: Yanishevsky, p. 43, pl. v, figs. 20 *a*, *b*.
1927. *Linoproductus tenuistriatus* (de Verneuil) Chao, p. 135, pl. xiv, figs. 5, 9-12.
1937. *Linoproductus tenuistriatus* (de Verneuil): Sarytcheva, p. 69, pl. vi, figs. 2 *a-c*, 3, 4.

This species is represented by about a dozen fragmentary specimens from Bukit Charas (loc. 5048 [BB. 7887-95]). These vary in size, the largest being 26.5 mm. long, 25.5 mm. wide, and 10 mm. thick (incomplete), but the average appears to be 23 mm. long, 20 mm. wide, and 15 mm. thick. The pedicle valve is highly convex, elongate-oval in outline, and tapers towards the umbo which is only slightly incurved. The hinge is approximately equal to the greatest width of the shell. The flanks slope up rather steeply to the venter, which is rounded. The shell is evenly curved postero-anteriorly, but the trail is not preserved entire in any specimen. The umbo tapers to an acute extremity and projects slightly beyond the hinge-margin. The ears are flattened and separated from the visceral disk by a shallow sulcus. Only one brachial valve was preserved and this lacked the trail. The visceral disk is very slightly concave, or convex as seen in reverse view. The ears are small and flattened and are separated from the visceral disk by a shallow sulcus. A geniculation probably separated the visceral disk and trail.

The shell is ornamented by very fine costae (about twenty-two in 10 mm.) on the middle of the venter about 20 mm. below the umbo. These are somewhat undulating and irregular in width due to the numerous intercalations developed over the entire shell surface. These intercalations only attain the normal width of the costae in about 2.5 mm. Most of the costae increase slightly in width anteriorly, but rarely a costa decreases in width owing to the development of two adjacent intercalations. Spine-bases are rare and of small diameter and two costae tend to unite immediately above the spine-base and to bifurcate again below. Only three spine-bases were observed on the venter in the best preserved specimen. The arrangement of the spines on the ears and hinge-margin is uncertain, but there are probably two rows, one set along the hinge-margin and the other at a slight angle to it. These spine-bases appear to be of the same diameter as those on the trail. From five to seven angular folds or rugae are developed on the ears and extend for a short distance over the lateral slopes, but flatten out rapidly, and are never visible on the venter. In the brachial valve these rugae were less prominent and narrower, and were faintly traceable across the visceral disk. In this valve the rugae are more irregularly developed, and may bifurcate near the hinge-margin. Growth-lines are numerous and rather prominent on the inner or reverse layers of the brachial valve.

Nothing is known of the internal structure.

REMARKS.—These Malayan specimens resemble the form commonly determined as *Productus tenuistriatus* in the Asiatic Lower Carboniferous, but rather doubtfully identified with de Verneuil's specimens from Cosatchi-Datchi, eastern slope of south Urals, which, according to Librovitich (1939), are of Namurian or Upper Visean age. In ornament, shell outline, and dimensions it resembles the specimen figured by Chao (1927, pl. xiv, fig. 5) from the Visean at Tung-Shan, Chang-Yi, eastern Yunnan, also the specimens (ibid., figs. 9-12) from the Upper Visean, Choniukou formation of Cho-Niu-Kou, Wu-Wei-Hsien, Kansu, north-west China. The small visceral cavity of this species is well shown in a longitudinal section of one of the Kansu specimens. Similar specimens were also figured by Gröber (1908) from an Upper Visean limestone near Sart-dschol Pass in the Terskei

Alatau Range, south of Lake Issyk-kul, Tian-shan, and by Yanishevsky (1918) from the Visean of Ferghana. It has also been recorded by Weber (1910) from the Visean of Ferghana between Margelan and Kokand; and by Krenkel (1913, p. 13) and Löweneck (1932) from the Visean of Basch-sugun, north-east of Kashgar, Sinkiang, south Tian-shan.

Specimens agreeing well with the largest of the Malayan forms were figured and described in Russian by Sarytcheva (1937, p. 69, pl. vi, figs. 2-4) from the Upper Visean, Serpukhovian, C^{srp}₁⁴, Protva Beds, of the Luja River, near Kremenskoye, Moscow Basin. This species has also been recorded from the Upper Visean of the Kizel district of West Urals by Gorsky and Timofeeva (1939).

It has also been figured by Tschernyschew (1902, p. 628, pl. xxxvi, figs. 4, 5; pl. lv., fig. 6) from the Uralian, *Schwagerina* Beds, of the western slopes of the Ural Mountains, but one of the forms figured is considerably larger and more elongated than the Asiatic form commonly identified as *L. tenuistriatus*.

L. tenuistriatus differs from *L. corrugatus* (M'Coy) and *L. cora* (d'Orb.) in its smaller dimensions, finer costation, and fewer spines. It differs from *L. ovatus* (Hall) from the Mississippian, St. Louis, and Chester Group, in the more rapid tapering of the shell posteriorly and less circular shell outline, also in its less numerous spine-bases on the venter, and less marked geniculation of the shell.

GENUS PROBOSCIDELLA Oehlert, 1887

GENOTYPE *Productus proboscideus* de Verneuil

***Proboscidella nana* sp. nov.**

(Pl. v, fig. 7)

1918. *Proboscidella*? sp. Yanishevsky, p. 60, pl. iii, figs. 11 a, b.

1918. *Proboscidella* cf. *proboscidea* (de Vern.): Yanishevsky, p. 59, pl. viii, fig. 15.

DIAGNOSIS.—*Proboscidella*, about 11.5 mm. long, 6.5 mm. wide, pedicle valve with flattened visceral disk and short tubular trail. Hinge line straight, equal to greatest width of shell. Ornament of about eleven prominent concentric ribs extending round the front of the visceral disk. Costae faintly developed on tube. Spines few on concentric ribs and in row along hinge.

TYPE-SPECIMEN.—Holotype, the single specimen from Bukit Sagu, Kuantan, Pahang [BB. 7839].

DIMENSIONS.—Maximum length, 11.5 mm.; maximum width, 6.5 mm.

DESCRIPTION.—The visceral disk of the pedicle valve is very slightly convex and separated from the flattened ears by a shallow depression. The flanks are steep and are united dorsally to form a short tube which is on the same plane as the visceral disk. The tube tapers anteriorly and is 3 mm. in length. The umbo is minute and like the brachial valve could not be detached from the matrix. The ornament consists of eleven narrow prominent ribs extending from the cardinal margin round the front of the visceral disk, and rarely bifurcating on the lateral slopes. The ribs increase slightly in width on the anterior part of the visceral disk. Costae are not developed on the visceral disk and are obscure on the trail. Spine-bases are poorly preserved, but two or three are seen on the summit of the ribs of the visceral disk, and a row of spines probably extended along the cardinal margin on either side of the umbo. These spines appear to have projected at right angles to the shell surface.

Internal characters are unknown.

REMARKS.—This small form is distinguished from *Proboscidella proboscidea* (de Vern.) by its much smaller dimensions, shorter tube, more prominent ribs, and more obscure costation. The prominent concentric ribs of the visceral disk in *P. nana* are more regular and bear fewer spine-bases than in *Productus nystianus* de Kon., in which a trail is sometimes developed.

Yanishevsky (1918, p. 59, pl. viii, fig. 15, and pl. iii, figs. 11 *a, b*) figures two small specimens as *Proboscidella* cf. *proboscidea* and *Proboscidella* sp. from the Lower Carboniferous, Viséan, of Ferghana, which resemble the Malayan specimen in form, dimensions, and length of trail. The figures, however, are poorly reproduced and the ornament is obscure, but concentric ribs with scattered spine-bases seem to ornament the trail as well as the visceral disk in *P.* cf. *proboscidea*. In *P.* sp. (pl. iii, figs. 11 *a, b*) the ribs appear to be similar in size and number to the Malayan form and costae are not seen. A second specimen figured as *Proboscidella* cf. *proboscidea* (ibid., pl. viii, fig. 16) is a larger shell with a longer trail resembling typical *P. proboscidea*. The description of these forms is, unfortunately, in Russian only.

GENUS SINUATELLA Muir-Wood, 1928

GENOTYPE *Leptaena sinuata* de Koninck

Sinuatella orientalis sp. nov.

(Pl. iv, figs. 1 *a-c*, 2 *a-c*)

DIAGNOSIS.—*Sinuatella* about 23 mm. long, 28 mm. wide, and 17 mm. thick, visceral disk slightly convex, separated from trail by geniculation. Trail with shallow median sinus. Flanks steep. Ornamented by prominent concentric ribs on visceral disk, and costae developed on anterior part of visceral disk and on trail. Spines in two rows on ears and cardinal slopes. Cardinal area, hinge-teeth and sockets, and delthyrium developed.

TYPE-SPECIMEN.—Holotype, from the Lower Carboniferous, Viséan, of Bukit Sagu, Kuantan, Pahang, Malaya [BB. 7841]. Paratypes from same locality [BB. 7842-4].

MATERIAL AND LOCALITY.—Six specimens, two from Bukit Tinggik [BB. 7845-6], and four from Bukit Sagu, Pahang [BB. 7841-4].

DIMENSIONS.—Holotype: maximum length, 22 mm.; maximum width, 25.5 mm.; maximum thickness, 16.5 mm. Paratype [BB. 7844]: maximum length, 23 mm.; maximum width, 27.8 mm.; maximum thickness, 17 mm.

DESCRIPTION.—The posterior part of the pedicle valve is inflated and separated from the small flattened ears by a shallow sulcus. At a distance of about 5 mm. from the umbo the valve flattens and a shallow median sinus is then developed, dividing the shell into two parts. The flanks are steep and almost at right angles to the visceral disk. The shell of the pedicle valve is much thickened. A narrow cardinal area and an indication of a triangular delthyrium were observed in one specimen. The exterior of the brachial valve was not seen. In reversed view the visceral disk is flattened and the trail in contact with that of the pedicle valve.

The ornament consists of about sixteen narrow prominent concentric ribs which extend round the front of the visceral disk and rarely bifurcate on the cardinal slopes.

The costae do not extend to the umbo, but are faintly developed about half-way down the length of the visceral disk, and are well seen on the trail. Slight enlargement of the costae occurs at the point of junction with the ribs, but reticulation is never marked. There are twelve costae in 10 mm. on the trail. Spine-bases are arranged in a row along the hinge, and in a second row set at an angle of 30° to it.

The cardinal process in the brachial valve is trifid, the middle prong extending beyond

the other two. Shallow hinge-sockets are developed on each side of the cardinal process and a fragment of a hinge-tooth is seen in one socket in the holotype. Other internal characters were not observed.

REMARKS.—*Sinuatella orientalis* is distinguished from *S. sinuata* (de Kon.) from the Visean, *Dibunophyllum* zone, of Belgium and England, by its slightly larger proportions, more massive shell, more convex visceral disk, shallower median sinus, more prominent ribs, and coarser costae. Specimens of *S. sinuata* agreeing well in size and ornament with the Belgian species have been figured by Nalivkin (1937, p. 68, pl. vii, fig. 12) from the Upper Visean, Yagovkin Beds of north-eastern Kazakhstan, Turkestan.

Sinuatella appears to be confined to the Lower Carboniferous. The specimens described by Licharew (1937, p. 116, pl. i, figs. 7-15) as *Sinuatella subsinuata* from the Permian of the Caucasus do not belong to this genus. It is doubtful also if the two species described by Paeckelmann (1931) as *Sinuatella beushauseni*, and *S. gaablauensis* from the Culm of Germany, are congeneric with *S. sinuata* and *S. orientalis*, although typical specimens of *S. sinuata* (de Kon.) are figured from the Culm of Hagen in Westphalia (Paeckelmann, 1931, p. 317, p. xl, figs. 3-5).

GENUS MARGINICINCTUS Sutton, 1938

1938 (Oct.). *Worthenella* Girty, p. 442 (non *Worthenella* Walcott, 1911, Vermes).

1938 (Nov.). *Marginicinctus* Sutton, p. 561.

1942a. *Worthenella* Girty: Sutton, p. 464.

1942b. *Marginicinctus* Sutton, p. 777.

GENOTYPE *Productus marginicinctus* Prout

REMARKS.—The name *Worthenella* Girty, with genotype *Productus wortheni* Hall, is preoccupied, and *Marginicinctus* Sutton with genotype *P. marginicinctus* Prout, and including also *P. wortheni* Hall, is, therefore, the valid name.

Marginicinctus? cf. *planus* (Yanishevsky)

(Pl. v, fig. 6)

cf. *Productus planus* Yanishevsky, 1910, p. 60, pl. v, figs. 2 b, c (non *vidi*).¹

cf. *Productus planus* Yan.: Yanishevsky, 1918, p. 41, pl. v, fig. 4.

One pedicle valve from Bukit Tinggik [BB. 7848] with small marginal ledge projecting almost at right angles to the visceral disk is referred to the genus *Marginicinctus*. The visceral disk is moderately convex and well demarcated from the small flattened ears by a deep sulcus. The hinge-line was probably equal to the greatest width of the shell, but is imperfectly preserved. The flanks are gently sloping and no median sinus is developed. The umbo is massive and slightly incurved.

The ornament consists of costae and concentric ribs which, being spaced at equal distances apart, cause a very regular reticulation at the point of intersection. There are about twenty narrow ribs of equal width which are continuous round the front of the visceral disk. The costae extend from about 1 mm. below the umbo and radiate out from the umbo with rare intercalations. There are ten costae in 5 mm. The costae and ribs continue on to the narrow marginal ledge. Spine-bases are developed as a group on the ears, but are also visible on the visceral disk.

Internal characters are unknown.

DIMENSIONS.—Length, 11.5 mm.; width, 13.5 mm.; thickness, 3.5 mm.

¹ No copy of this work in Great Britain.

REMARKS.—This species is doubtfully referred to the genus *Marginicinctus* which was proposed by Sutton (1938, p. 561) for the species *Productus marginicinctus* Prout and *Productus wortheni* Hall from the American Mississippian, both of which have a well-developed horizontal rim round the anterior margin of the shell. *Productus projectus* Muir-Wood from the Visean of Little Island, Cork, and Derbyshire, should be referred to the same genus, if this marginal ledge is not merely a gerontic trend in development in different stocks. That this is probably the case is indicated in the British Carboniferous species where a horizontal rim is developed in *P. projectus* with *Dictyoclostus* ornament, and in a species having *Buxtonia* ornament. Similarly, *P. marginicinctus* Prout appears to have *Buxtonia* ornament, and *P. wortheni* Hall *Dictyoclostus* ornament, while *P. setiger* Hall, which has been assigned to a new genus *Setigerella* [= *Setigerites*] by Girty (1938) has *Linoproductus* type of ornament, but with more numerous spines developed in both valves. The development of this structure is discussed briefly by Sutton (1942a) who describes it in a number of American species as varying from a horizontal rim extending at right angles to the shell surface, to a concave trough, or even a tube. Until the whole question can be examined thoroughly, it would appear to be necessary to retain the genus *Marginicinctus* Sutton, and also *Setigerites* Girty, since the ornament in the genotype, *P. setiger* Hall, appears to be distinct from that of species of *Linoproductus* and *Buxtonia*, and the interior of the brachial valve does not show the distinct posterior bifurcation of the median septum (ref. Muir-Wood, 1928, pl. xii, fig. 21) of *Buxtonia* to which genus *P. setiger* is re-assigned by Sutton (1942a). The Malayan form appears to resemble *P. wortheni* from the Keokuk Limestone most closely, but it has a less convex visceral disk and better defined ribs.

Proboscidella kutorgae Tschernyschew (1902, p. 643, pl. lix, figs. 1-3, and pl. xxxi, figs. 2, 3) from the Uralian, *Schwagerina* limestone of the Ural Mountains, has a horizontal rim round the anterior and lateral margins of the visceral disk. This rim is then deflected anteriorly and produced to form a short trail, the median part of which tends to form a tube. This species may represent a further stage in the development of this genus. The ornament of the visceral disk resembles that of the Malayan form, but it is more laterally elongated and quadrate in outline.

Yanishevsky (1918, p. 41, pl. v, fig. 4) figured a larger specimen with similar ornament from the Visean, D₃, of Ferghana. It is uncertain, however, if a horizontal rim is developed in this form which is briefly described in Russian. The original description and figures of Yanishevsky's species from the region of Orenburg, Russia, were not available.

Order TELOTREMATA

Superfamily RHYNCHONELLACEA

Family CAMAROTOECHIIDAE

GENUS PUGNAX Hall & Clark, 1894

GENOTYPE *Anomites acuminatus* Martin

***Pugnax asiaticus* sp. nov.**

(Pl. vi, figs. 3 a-c, 4 a-c)

1924. *Pugnax acuminatus* (Martin): Hayasaka, p. 35, pl. v, figs. 14-16.

DIAGNOSIS.—*Pugnax*, about 23 mm. long, 25 mm. wide, and 15 mm. thick, trigonal in outline and in lateral contour, brachial valve highly arched, pedicle valve correspondingly

concave. Linguiform extension about 22 mm. long, trigonal-subpentagonal in outline, acuminate. Plications not developed on lateral slopes. Apical angle about 160° .

TYPE-SPECIMEN.—Holotype [BB. 7823] from the Visean of Bukit Tinggik, Pahang. Paratype from same locality [BB. 7825].

MATERIAL AND LOCALITY.—Three specimens from Bukit Tinggik [BB. 7823-5].

DIMENSIONS.—Holotype: maximum length, 24 mm.; maximum width, 25.5 mm.; maximum thickness, 15 mm. Paratype [BB. 7825]: maximum length, 24.5 mm.; maximum width, 30 mm. (approx.); maximum thickness, 18 mm.

DESCRIPTION.—The brachial valve is convex in early growth-stages and the shell circular to laterally-oval in outline. At a length of about 12 mm. the shell is medianly arched, and this ridge becomes more angular and prominent in the gerontic stage. The lateral slopes now curve steeply down from the median ridge and flatten anteriorly. The ventral umbo is not preserved in any specimen, but the posterior part of this valve is convex. It becomes concave about 5 mm. below the umbo, the concavity increasing in depth anteriorly. The length of the linguiform extension is almost as great as the length of the entire valve. The anterior part of the pedicle valve is geniculated almost at right angles to the posterior part of the shell. In dorsal view the shell is approximately trigonal in outline with a median anterior notch. In lateral view it is subtrigonal in outline with the anterior side of the triangle regularly curved and meeting the posterior dorsal side of the triangle at a right angle. The third or posterior ventral side curves to join the anterior side.

The valves are comparatively thin-shelled and lack ornament. Fine growth-lines are visible on the holotype.

INTERNAL CHARACTERS.—No median septum was observed in the brachial valve. In the pedicle valve curved and slightly converging dental lamellae were seen in one specimen.

REMARKS.—*Pugnax asiaticus* is distinguished from *P. acuminatus* (Martin), the genotype of *Pugnax* from the Lower Carboniferous, Visean, D, S and ?C knolls of England, Ireland, Belgium, etc., by the smaller dimensions of the adult shell, narrower body cavity, more concave pedicle valve, more even curvature of flanks of brachial valve on to median ridge which is not demarcated by a sulcus in the Malayan species. In dorsal view the lateral margins are regularly curved, while in *P. acuminatus* there is slight pinching in of the anterior part of the shell. The lateral contour also differs in the two species. It differs from *P. acuminatus* var. *klenovi* Semichatova (1935) from the Visean of Novaya Zemlya, by its narrower shell, steeper flanks, and longer linguiform extension.

Pugnax asiaticus differs from *P. mesogonus* (Phillips) from the Lower Carboniferous, ? S and C zones of Lancashire, Yorkshire, etc., in the lack of the single plication on the lateral slope, as well as in the general shape and lateral contour of the shell.

The specimen figured by Yanishevsky (1918, p. 68, pl. vi, figs. 22 a, b) from the Lower Carboniferous of Ferghana, Russian Turkestan, resembles *P. asiaticus* in dimensions, but differs from it in dorsal and ventral contour of the shell, and in having a more concave pedicle valve in the umbonal region.

The specimen figured by Hayasaka as *Pugnax acuminatus* (1924, p. 35, pl. v, figs. 14-16) from the Lower Carboniferous, ?Visean, of Omi-mura, Echigo, west Japan, closely resembles *P. asiaticus* in shell outline and convexity of valves. The linguiform extension of the pedicle valve tapers in a similar acute angle. As depicted in the figure, the specimen appears to be about twice the size of the Malayan form. The dimensions quoted by Hayasaka as: length 28 mm. and width 31 mm. are, however, similar to those of *P. asiaticus*. The depth, 39 mm. (lateral-anterior margins), appears to be taken from what is presumed to be an enlarged drawing. Only one specimen is figured by Hayasaka, and its precise horizon is unknown, but it is suggested that it is probably Visean.

"*Rhynchonella*" *acuminata* was recorded by Yanishevsky (1900, p. 162) from the Lower Carboniferous of the eastern Urals from C_1^{2a} or C_1^{1a} , and by Rotai (1931, p. 71) from the Beschevo Limestone (=D₃ subzone of England) of the Donetz Basin, Russia. It is uncertain whether these Russian forms are typical of Martin's species, or if they resemble *P. asiaticus*.

R. acuminata was also recorded by Krenkel (1913) from the Visean, D₂ subzone of southern and eastern Tian-shan, especially from Basch-sugun, north-east of Kashgar. This specimen is said to correspond with Davidson's shell figured in 1861 (pl. xx, figs. 4 a, b), which resembles *P. asiaticus* in lateral contour, but its dimensions are about twice those of the Malayan shell.

R. acuminata was recorded by Mouchkétov (1915) from the Visean of eastern Ferghana, near the town of Osh, where it is associated with *Productus giganteus* and *P. latissimus*, and by Löweneck (1932) from Tian-shan. It was also recorded by Jarosz (1928) from the Lower Carboniferous of the Cracow district, Poland. The specimen figured by Termier (1936, pl. xvi, figs. 3 a-c) from the Visean of Morocco does not belong to the *P. acuminatus* group, but is near to *P. platilobus* (J. de C. Sow.).

Pugnax cf. pugnus (Martin)

(Pl. vi, figs. 2 a, b)

cf. *Conchylolithus Anomites (pugnus)* Martin, 1809, p. 13, pl. xxii, figs. 4, 5.

cf. *Rhynchonella pugnus* Martin: Davidson, 1861, p. 97, pl. xxii, figs. 1, 2.

One imperfect specimen [BB. 7826] from Bukit Tinggik, lacking the posterior portion of both valves, resembles specimens of *P. pugnus* (Martin) from the British Visean, D₂ subzone. The posterior part of the shell is smooth in both valves, the brachial valve being convex and the pedicle valve slightly concave. A single plication is developed on each dorsal lateral slope, and shallow sulci demarcate the median fold which is ornamented by four broad angular plications. These plications extend posteriorly for 10 mm., and increase in width and prominence anteriorly. The ventral median sinus is ornamented by three rounded plications which extend for a distance of 12 mm., and alternate with those of the dorsal valve. A single rounded plica is also developed on each ventral lateral slope. The linguiform extension of the pedicle valve is 15 mm. in length and medianly flattened.

The length of the shell is approximately 18 mm.; width, 22 mm.; and thickness, 16 mm.

The internal structure is unknown.

REMARKS.—The ornament, dimensions, and outline of the shell of the Malayan specimen are very similar to those of the British and Belgian Lower Carboniferous, Visean, C₂-D₂ specimens of *Pugnax pugnus* (Martin). The pedicle valve is, however, slightly more concave in most British specimens. Martin's type from the D₂ subzone of Derbyshire is a slightly larger shell ornamented by five angular plications on the median fold and four in the sinus.

The specimens figured by Yanishevsky (1918, p. 69, pl. vii, figs. 1 a, b) as *P. cf. pugnus* from the Lower Carboniferous (=D₃) of Ferghana, Russian Turkestan, resemble the Malayan form in general dimensions, but differ from it in having only three plications on the median fold and two in the sinus.

De Verneuil (1845, p. 78, pl. x, figs. 1 a, b) records this species from the Carboniferous Limestone of Cosatchi Datchi on the eastern slope of the Ural Mountains, east of Miask. No locality is given, however, for his figured specimen, which is similar to the Malayan specimen in form and ornament.

Superfamily SPIRIFERACEA

Family SPIRIFERIDAE

GENUS BRACHYTHYRIS M'Coy, 1844

Syn. *Ovalia* Nalivkin, 1937, p. 107 (as subgenus of *Spirifer* with genotype *S. ovalis*)

GENOTYPE *Spirifera ovalis* Phillips

REMARKS.—M'Coy defined this genus as having "Hinge-line shorter than the width of the shell; cardinal area small, curved, triangular: surface ribbed longitudinally". The genus was re-defined by T. N. George (1927, p. 107) as "Radially ribbed; hinge-line shorter than the width of the shell; no dental plates; mesial fold divided by a median groove."

Brachythyris ? buckmani Yanishevsky

(Pl. ix, figs. 4 a-c)

1918. *Brachythyris buckmani* Yanishevsky, p. 137, pl. viii, figs. 41, 46.

1932. *Brachythyris buckmani* Yanishevsky: Löweneck, p. 67, pl. ii, figs. 4 a, b.

One smooth Spiriferid without dental lamellae from Bukit Sagu [BB. 7772] is doubtfully referred to Yanishevsky's species from the Visean (=D₃) of Ferghana. The shell is subpentagonal in outline, both valves are convex with a low median fold in the brachial valve, and a shallow sinus in the pedicle valve. A short rounded linguiform extension is developed in the pedicle valve. The dorsal median fold increases very slightly in elevation anteriorly and is separated from the lateral slopes by a shallow depression. The ventral umbo is rounded and incurved over the narrow triangular area, which is imperfectly preserved. The shell is smooth with the exception of growth-lines.

DIMENSIONS.—Length, 19.5 mm.; width, 19.5 mm.; thickness, 13.3 mm.

REMARKS.—Yanishevsky gave no description of his species beyond stating that it is a smooth *Spirifer* "provided with a sinus on the ventral valve producing a considerable curvature of the frontal margin." The figures given are poor, but the dimensions, shell outline, and lack of ornament appear to be similar to those of the Malayan specimen. The genus to which this species belongs is uncertain. No apical plates are developed in the Malayan specimen, but no mention of internal characters is made by Yanishevsky.

Löweneck (1932) figured this species from Basch-tsachma in southern Tian-shan.

Brachythyris koksensis Dikareva

(Pl. x, figs. 4-6)

1918. *Spirifer* sp. (No. 4) Yanishevsky, p. 83, pl. v, fig. 37.

1937. *Brachythyris suborbicularis* Hall mut. *koksensis* Dikareva, p. 35, pl. v, figs. 1, 4.

Two fragments of a large convex pedicle valve from Bukit Sagu [BB. 7818-9] and a brachial valve from Bukit Tinggik [BB. 7821] should probably be identified as *Brachythyris koksensis* described by Dikareva from the Middle Visean (probably=D₂ subzone) of Koks River, Chatkal Mountains, Ferghana, Russian Turkestan.

The umbo, imperfectly preserved in one specimen, is massive and incurved, and a shallow sinus apparently extended from the umbo anteriorly. The shell is elongate-oval

in outline, but the hinge and cardinal extremities are not preserved. The costae are flattened, wide (5 mm. in width about 30 mm. from the umbo), prominent, separated by sulci about one-fifth of the width of the costae. There are four to five costae in the sinus and from five to six on each flank. The cardinal slopes are smooth. No dental lamellae are developed.

The dimensions of the larger pedicle valve are: length 71 mm.; width (approx.) 67 mm.; thickness 30 mm.

The brachial valve which is doubtfully referred to this species is 40 mm. long, 57 mm. wide, and 15 mm. thick. The shell is very slightly convex, due partly to crushing, and is wider than long with rounded cardinal extremities. The median fold is prominent anteriorly and separated from the lateral slopes by a narrow deep sulcus. The ornament consists of broad rounded costae, about five on the fold, five to six on each lateral slope. These costae are separated by rather wide sulci and increase rapidly in width towards the anterior margin, the greatest width being 4 mm.

REMARKS.—The large pedicle valve figured by Dikareva (1937, p. 35, pl. v, figs. 1, 1 a) as *Brachythyris suborbicularis* mut. *koksuiensis* from the Chatkal Mountains, Ferghana, resembles the Malayan form in the contour of the pedicle valve, in dimensions, shallow sinus, and broad costae. No description of this variety is given by Dikareva owing to lack of material, but it is said to differ from Hall's species by its larger dimensions, sharper and more convex plicae, and more inflated ventral valve. The Chatkal Mountains form, however, appears to be quite distinct from Hall's species from the Mississippian. Dikareva's specimen (pl. v, fig. 1) is 70 mm. long, 65 mm. wide, and 28 mm. thick. These dimensions are similar to those of the larger pedicle valve from Malaya. One costa, seen on the posterior part of the shell, is 6 mm. wide, but the ornament of the Ferghana specimen is imperfectly preserved owing to decortication. A smaller brachial valve from Ferghana (fig. 4) has a broad median fold with three flattened costae and about seven narrower costae on each flank.

Yanishevsky (1918, p. 83, pl. v, fig. 37) figured as *Spirifer* sp. an imperfect pedicle valve with coarse costation which probably belongs to Dikareva's species. This specimen which is from the Viséan, ?D₂ subzone of Ferghana, Russian Turkestan, is 52 mm. long and 62 mm. wide, and has six costae within the broad sinus, and five to six on each flank. These costae are broad and flattened, some attaining a width of 5 mm. anteriorly and separated by narrow sulci about one-fifth of the width of the costae.

Some specimens of *Brachythyris subrotundata* (M'Coy) from the British Lower Carboniferous have costae of comparable width, but the median fold is less plicated, the sinus broader, and the shell more laterally elongated than in the Malayan specimens.

***Brachythyris willbourni*¹ sp. nov.**

(Pl. viii, figs. 1, 2, 3 a, b)

cf. *Spirifer bisulcatus* Sowerby: Romanowsky, 1880, p. 104, pl. xv, figs. 5 a, b.

DIAGNOSIS.—*Brachythyris*, about 40 mm. long, 50 mm. wide, and 25 mm. thick, transversely oval in outline, both valves moderately convex, cardinal extremities rounded, cardinal area slightly less than greatest width of shell. Costae broad rounded, not prominent, seven posteriorly on each lateral slope, increasing by bifurcations to twelve. Median fold low, divided by narrow median groove, ornamented by four or more costae. Median sinus shallow with four to six costae anteriorly. Growth-lines forming fine, even, concentric ornament. Apical angle 125°.

¹ Named after Mr. E. S. Willbourn, former Director of the Malayan Geological Survey.

TYPE-SPECIMEN.—Holotype, a pedicle valve from Bukit Sagu [BB. 7801]. Paratypes, brachial valves No. BB. 7800 from same locality, and No. BB. 7806 from Bukit Tinggik.

MATERIAL AND LOCALITY.—Eighteen imperfect specimens, including seven brachial valves and eleven pedicle valves. One specimen from Bukit Charas [BB. 7805], eight from Bukit Sagu [BB. 7800-4, 7811-13], and five from Bukit Tinggik [BB. 7806-10]. Four specimens from Bukit Sagu in the collection of the Malayan Geological Survey.

DIMENSIONS.—Holotype, length, 38.8 mm.; width (approx.), 50 mm.; thickness (pedicle valve), 16.4 mm. Paratype [BB. 7800]: length, 31.8 mm.; width (approx.), 43.2 mm.; thickness (approx.), 25 mm.

DESCRIPTION.—In early growth-stages the pedicle valve is convex with a narrow median sinus extending from about 4 mm. below the umbo. The sinus increases in width in later growth-stages, but is always shallow and not well demarcated from the lateral slopes. The umbo tapers acutely and is slightly incurved over the cardinal area. The latter is not preserved entire in any specimen, but apparently tapered laterally and was transversely striated. In young specimens the cardinal extremities are rounded, but there is a tendency for them to become acute in the gerontic stage when the hinge is approximately equal to the greatest width of the shell.

The brachial valve is considerably less convex than the pedicle valve, and is evenly curved transversely and longitudinally. The median fold is developed about 5 mm. below the umbo, but is never prominent, and causes only a slight dorsal deflection of the anterior commissure.

The umbonal and cardinal slopes of both valves are smooth. In the brachial valve there are six or seven primary rounded costae on each lateral slope extending from the umbonal slopes. Each costa may bifurcate resulting in twelve to fourteen costae of unequal width at the anterior margin. The costae are separated by shallow sulci about one-quarter of the width of the costae. The median fold is ornamented posteriorly by two costae separated by a narrow furrow which extends along the entire length of the fold. Each of these costae may bifurcate or trifurcate, resulting in four to six costae at the anterior margin.

In the pedicle valve there are about twelve costae at the anterior margin of each lateral slope, and five to six in the median sinus. The latter are produced by the bifurcation of two costae on the lateral margins of the sinus. No costa is developed in the centre of the sinus. The growth-lines form a fine closely-spaced transverse ornament. No capillation is developed.

INTERNAL CHARACTERS.—No dental lamellae are developed. Other internal characters unknown.

REMARKS.—*Brachythyris willbourni* differs from *Spirifer bisulcatus* Sowerby from the British Visean, D₂ subzone, in its less convex valves, more rounded cardinal extremities, in its broader, more flattened costae which are not capillate, and in its low, broad, median fold with a median groove.

It differs from *Brachythyris subrotundata* M'Coy in its smaller dimensions and less convex valves and median fold, and in its more numerous and narrower costae. *Brachythyris pinguis* (J. Sowerby), also from the British Dinantian, is considerably more convex, less elongate laterally, and has the median fold subdivided by a median groove, but not ornamented by additional costae. *B. willbourni* is distinguished from *B. ovalis* (Phillips) by the greater width of the shell, longer cardinal area, and by the costation of the median fold. The specimen figured by Romanowsky (1880, pl. xv, figs. 5 a, b) as *Spirifer bisulcatus* from the Carboniferous Limestone near the River Borgusta in Kuldja, Turkestan, should probably be identified as *B. willbourni*.

The specimen figured by Sergunkova (1935, p. 20, pl. v, figs. 5 a, b, c) as *Brachythyris*

ovalis from horizon C (=D₁ subzone) of the Talassic Alatau Range, Tian-shan, is smaller and less elongate laterally, and is more coarsely costate than specimens of *B. willbourni*.

Weber (1910, p. 625) records *Spirifer* ex gr. *pinguis* aff. *integricostus* Phill. from the Lower Carboniferous [Visean] of Margelan and Kokand districts of Ferghana, Turkestan. These specimens should probably be identified in part as *Brachythyris willbourni*. The two pedicle valves poorly figured by Nalivkin (1937, pl. xxvii, figs. 6, 10) as *Spirifer* aff. *integricostus* Phill. from the Visean, Ishim, and Yagovkin Beds of the Dzezkazgan district of Kazakhstan, Turkestan, should possibly be identified as *B. willbourni*. Two silicified pedicle valves from the Lower Carboniferous of Sart-dschol Pass of Tian-shan, figured by Gröber (1909, pl. iii, figs. 3, 4) as *S. bisulcatus*, are similarly ornamented and have the same shell outline as the Malayan specimens. Two imperfect pedicle valves figured by Gröber in 1908 (pl. xxvi, figs. 8-10) from the same locality as *S. bisulcatus* are also comparable to *B. willbourni*.

The specimens figured by Mansuy (1913d, p. 32, pl. v, figs. 4 a-g) as *Spirifer bisulcatus* from the Lower Carboniferous of Nong-po, Tran-ninh, Laos, Indo-China, differing from *Brachythyris willbourni* in their smaller dimensions, more alate shell outline and finer costation, appear to be closely related to *S. semicircularis* Phillips.

The pedicle valve figured by Frech (1916, p. 252, pl. viii, fig. 7) as *Spirifer bisulcatus* from the Visean of Karapunar, Belemelik, Taurus on the Bagdad railway, Asia Minor, resembles specimens of *B. willbourni*, both in dimensions, outline of shell, and costation.

One imperfect pedicle valve figured by Yanishevsky (1918, p. 82, pl. vi, fig. 1) as *S. bisulcatus* from the Visean of Ferghana, Russian Turkestan, appears to have similar costation to that of *B. willbourni*. Also the two imperfect specimens figured by Dikareva (1937, p. 25, pl. v, figs. 5, 6) as *B. aff. varians* and the specimen of *B. integricosta* (1937, pl. iv, fig. 3) from the Upper Visean of the Chatkal Mountains, Ferghana, should probably be identified as *B. willbourni*.

Spirifer (Anelasma) varians figured by Rotai (1931, p. 131, pl. ix, figs. 1-5) from the Visean, C₁² (?=D₃ subzone of England) of the Donetz Basin, Russia, resembles *B. willbourni* in its general form and ornament and in non-development of dental lamellae in the pedicle valve. It differs from the Malayan species in its more prominent median fold, parallel-sided cardinal area, more acute cardinal extremities, and in the development of a median costa within the ventral median sinus.

GENUS CHORISTITES Fischer de Waldheim, 1825

GENOTYPE *C. mosquensis* Fischer

cf. *Choristites? humerosus* (Phillips)

(Pl. viii, fig. 7)

cf. *Spirifera humerosa* Phillips, 1836, p. 218, pl. xi, fig. 8.

cf. *Spirifera humerosa* Phillips: Davidson, 1858, p. 23, pl. iv, figs. 15, 16.

cf. *Spirifer humerosus* Phillips: Hayasaka, 1924, p. 42, pl. vi, figs. 1-5.

One imperfect pedicle valve [BB. 7816] from Bukit Tinggik has a broad shallow median sinus, tapering linguiform extension, and regular bifurcating costae as in *Choristites? humerosus* (Phill.) from the British Visean. A small portion only of the brachial valve is preserved, but enough to show that both valves were convex in lateral view. The umbo is partially preserved, and is massive and incurved beyond the hinge-line. The flanks are imperfect, but the cardinal extremities appear to have been rounded and the shell to have

been longer than wide. The sinus commences about 10 mm. from the umbo and increases considerably in width and depth towards the anterior margin. It is not sharply demarcated from the lateral slopes.

The ornament consists of rather regular costae which occasionally bifurcate. About ten costae occupy the sinus, and there are six in 10 mm. on the lateral slopes. Concentric growth-lines are not well preserved. Owing to decortication of the shell the costae often appear to be approximately the same width as the sulci, but in better-preserved parts of the shell the costae are flattened and the sulci about one-third of their width.

One dental lamella could be seen, and this was about 11 mm. in length, and extended at an angle of about 5° to the vertical.

REMARKS.—This fragmentary specimen resembles examples of Phillips's species, from the *Dibunophyllum* zone of England and Wales, in its proportions, contour, and ornament. The dental lamella diverging at a low angle from the umbo is similar to those observed in Phillips's species, which is doubtfully referred to the genus *Choristites*.

Spirifer humerosus was figured by Hayasaka (1924, p. 42, pl. vi, figs. 1-3) from the Lower Carboniferous of Omi-mura, Echigo, western Japan. The exact horizon of this specimen is unknown. Both valves are preserved and the pedicle valve appears to be more convex than in British specimens or in the Malayan shell, but the dimensions and ornament are similar.

GENUS NEOSPIRIFER Fredericks, 1924

GENOTYPE *Spirifer fasciger* Keyserling

***Neospirifer derjawini* (Yanishevsky)**

(Pl. vii, figs. 2 a-d, 4)

1915. *Spirifer sibiricus* Yanishevsky, p. 44, pl. iv, figs. 1-4 (non Tschernyschew, 1893).

1918. *Spirifer derjawini* Yanishevsky, p. 81, pl. vii, figs. 30, 31.

Three imperfect specimens and two impressions of the brachial valve closely resemble Yanishevsky's species *Spirifer derjawini* from the Visean (=D₃ subzone) of Ferghana, Russian Turkestan. This species is referred to the genus *Neospirifer* on account of the incipient grouping of the costae into fascicles and of the prominent imbricating growth lamellae. The shell is laterally elongated, probably alate, but the cardinal extremities are not preserved in any specimen. The cardinal area is narrow, tapering very slightly laterally, and it probably formed the widest part of the shell. The ventral umbo is acute and sub-erect. A deep median sinus is developed just below the umbo and increases considerably in width anteriorly. The two costae bordering the sinus posteriorly are very prominent, but bifurcate or trifurcate anteriorly. There are about ten to eleven costae within the sinus anteriorly in the ventral valve and eighteen to twenty costae on each flank, of which only six or seven extend to the umbo, the remainder being developed as bifurcations or intercalations. In early growth-stages the anterior commissure is deflected dorsally by the median fold in a rounded lobe.

The brachial valve is less convex than the pedicle valve, and has a well-defined rounded median fold, ornamented anteriorly by about ten costae, all of which are derived from one primary costa by repeated bifurcations. There are seventeen to eighteen costae on each lateral slope, of which only about six extend to the umbo. These primary costae bifurcate or trifurcate to form groups or fascicles of costae which, however, do not form longitudinal ridges, except in one pedicle valve. In this specimen the costae bordering the sinus are

exceptionally broad and prominent, and trifurcate anteriorly. Growth-lines form a prominent transverse ornament of imbricating lamellae.

Internal characters are unknown.

DIMENSIONS.—Specimen No. **BB. 7791**: maximum length, 20.5 mm.; maximum width (approx.), 36 mm.; maximum thickness, 14.5 mm.

MATERIAL AND LOCALITY.—Four specimens from the Lower Carboniferous, Visean, of Bukit Sagu [**BB. 7789-91, 7802**], and one from Bukit Tinggik [**BB. 7792**].

REMARKS.—*Neospirifer derjawini* resembles *N. fasciger* (Keyserling) from the Uralian in the prominence of the costae bordering the sinus and the tendency to group the costae into fascicles. In *N. fasciger*, however, the fascicles are more prominent and often form longitudinal ridges. The shell also attains a larger size and the two valves are more convex. This characteristic of the costation can be paralleled in species of *Neospirifer* from the Permian of Texas as figured by King (1930).

The Malayan specimens closely resemble the pedicle valve figured by Yanishevsky (1918) from the Visean, D₃ subzone, of Ferghana as *Spirifer derjawini*. This pedicle valve is 18 mm. long, approximately 22 mm. wide, and there are sixteen to seventeen costae on each lateral slope and eleven costae in the sinus. It is probable that this specimen is immature, but it resembles the Malayan specimens in shell outline, width and depth of sinus and in ornament. The small brachial valve doubtfully referred by Yanishevsky to *S. derjawini* may belong to an immature specimen.

The two specimens figured by Yanishevsky in 1915 as *Spirifer sibiricus* (pp. 44, 92, pl. iv, figs. 1-4) from the Visean near Tomsk, Siberia, are referred in 1918 to *S. derjawini*. These Siberian specimens differ from the Malayan forms in their more alate shell outline and larger dimensions, also in their slightly coarser costation. The costae tend to be similarly grouped in fascicles, though in none of the Siberian specimens are the costae bordering the sinus so prominent as in one of the Malayan specimens. The prominent lamellose concentric ornament which is so well developed in the Malayan specimen is also characteristic of the Tomsk and Ferghana specimens of *S. derjawini*.

No description of the internal characters is given by Yanishevsky in 1915 or 1918.

GENUS SPIRIFER J. Sowerby, 1916 (sens. lat.)

Spirifer cf. *condor* d'Orbigny

(Pl. viii, figs. 4, 5)

cf. *Spirifer condor* d'Orbigny, 1842, p. 46, pl. v, figs. 11-14.

cf. *Spirifer condor* d'Orbigny: Tschernyschew, 1902, p. 531, pl. xxxviii, figs. 1, 2; pl. xii, figs. 1, 2.

cf. *Spirifer condor* d'Orbigny: Kozłowski, 1914, p. 67, pl. vii, figs. 10-14.

cf. *Spirifer condor* d'Orbigny: King, 1930, p. 113, pl. xxxv, figs. 8-10; pl. xxxvi, fig. 1.

Three imperfect specimens consisting of two detached pedicle valves and one brachial valve resemble *Spirifer condor* d'Orbigny from the Lower Permian of Bolivia, Uralian of Timan, and Lower Permian of Texas. All three specimens are alate, with the width approximately equal to twice the length. The hinge forms the widest part of the shell. The gently curved cardinal area is about 5 mm. in width, transversely striated, and tapers very slightly towards the cardinal extremities. The median sinus is broad and shallow, and scarcely demarcated from the lateral slopes, while the dorsal median fold, though better defined anteriorly, forms only a low rounded ridge. The anterior commissure is medianly deflected dorsally in a broad, almost rectangular, lobe. The umbo is not preserved intact in any specimen.

The ornament consists of rather fine rounded costae with eight to ten in the sinus

and about twenty-four on each flank. In the brachial valve there are ten costae on the median fold anteriorly, and twenty-four on each lateral slope. Bifurcations are not very numerous, and most of the costae are simple and extend from the umbonal slopes. Growth-lines form a regular prominent concentric ornament, but owing to the decortication of the shell are not conspicuous. Dental lamellae are developed in the pedicle valve.

DIMENSIONS.—Specimen No. **BB. 7815**: maximum length, 48 mm.; maximum width, 95 mm.; maximum thickness (pedicle valve only), 18 mm.

MATERIAL AND LOCALITY.—Three specimens from Bukit Sagu, Pahang [**BB. 7814-5, 7822**].

REMARKS.—The Malayan specimens resemble *S. condor* d'Orbigny in dimensions, shell outline, broad cardinal area, and costation, but the valves are less convex, the median fold narrower and less well demarcated, and the anterior commissure less arched medianly than in d'Orbigny's species.

The ornament and shell outline of the imperfect brachial valve figured by Yanishevsky (1918, p. 104, pl. iv, fig. 4) as *Cyrtina?* sp. from the Visean of Ferghana, closely resemble those of *S. cf. condor* from Malaya.

The alate specimen figured by Douvillé as *S. striatus* (1904b, p. 196, pl. xxv, fig. 5) from the Lower Carboniferous of Tunakabun and Imam Zada Hachim, Elburz Mountains, north Persia, differ from the Malayan forms in its smaller dimensions and shallow median sinus. The costation, however, is similar in the two forms. The brachial valve figured by Douvillé (fig. 6) may belong to a species of *Syringothyris*.

S. cf. condor resembles specimens of *S. mortonanus* Miller, figured by Nalivkin (1937, p. 104, pl. xxxi, figs. 1-4) from the Upper Visean, Yagovkin Beds of Dzezkazgan district of north-eastern Kazakhstan, near Lake Balkhash. The alate outline of the shell is similar, but the costae bifurcate more frequently, and are more prominent in Nalivkin's specimens.

***Spirifer scrivenori*¹ sp. nov.**

(Pl. vii, figs. 1 a-c, 3 a-c)

1918. *Spirifer duplicicosta* Phillips?: Yanishevsky, p. 85, pl. viii, fig. 4.

DIAGNOSIS.—*Spirifer*, about 35 mm. long, 70 mm. wide, and 27 mm. thick, laterally elongated, pedicle valve more convex than brachial valve, median fold prominent, angular, median sinus deep and broad. Linguiform extension short, triangular with acute apex. Cardinal area forming widest part of shell, tapering to rounded cardinal extremities. Ornament of concentric growth-lines, and about fifteen to twenty narrow rounded costae on each lateral slope, eight on fold and nine to ten in sinus, with rather numerous bifurcations and intercalations posteriorly. Apical angle 100°.

TYPE-SPECIMEN.—Holotype, preserved in British Museum (Nat. Hist.) from the Visean of Bukit Sagu [**BB. 7793**]. Paratype from the same locality [**BB. 7794**].

MATERIAL AND LOCALITY.—Eight imperfect specimens, seven from the Upper Visean of Bukit Sagu [**BB. 7793-8, 7820**], and one fragment from Bukit Tinggik [**BB. 7799**].

DIMENSIONS.—Holotype (slightly immature) [**BB. 7793**]: maximum length, 23.8 mm.; maximum width, 40.3 mm.; maximum thickness, 17 mm. Specimen No. **BB. 7794**: maximum length (approx.), 35 mm.; maximum width (approx.), 70 mm.; maximum thickness, 27 mm.

DESCRIPTION.—The eight specimens, though imperfectly preserved, have the two valves attached. Five of these specimens are probably immature. The shell is laterally

¹ Named after Mr. J. B. Scrivenor, former Director of the Malayan Geol. Survey.

elongated with prominent acuminate median fold and deep median sinus and slightly convex lateral slopes. The ventral umbo tapers to an acute extremity which is slightly incurved over the cardinal area. The latter is gently curved and tapers towards the rounded cardinal extremities. The hinge forms the greatest width of the shell. The delthyrium and deltidial plates could not be observed. The median sinus is developed about 3 mm. below the umbo, and continues anteriorly as a deep median sulcus which slopes gently up to the flanks from which it is not sharply demarcated. The linguiform extension of the pedicle valve is short and tapers rapidly to an acute extremity.

In the brachial valve the median fold is traceable from the umbonal slopes, but remains narrow and rounded until about 8 mm. from the anterior margin, when it broadens and projects medianly as an angular ridge, but is not sharply differentiated from the lateral slopes.

There are about forty costae, including eight on the fold, at the anterior margin of the adult shell. Of these, only about twelve extend to the umbo, the remainder being developed as intercalations or bifurcations. The costae are narrow and rounded and fairly even in width, and are separated by sulci which are slightly narrower than the costae. There are nine to ten costae within the ventral sinus. Owing to decortication of the shell growth-lines are not well preserved, but they apparently formed a well-marked concentric ornament at least within the sulci.

INTERNAL CHARACTERS.—Widely diverging dental lamellae are present in the pedicle valve. Other internal characters are unknown.

REMARKS.—*S. scrivenori* resembles the specimens figured by Nalivkin (1937, pl. xxxii, figs. 1, 2) as *Spirifer logani* Hall from the Upper Visean, Yagovkin Beds, of Dzekkazgan district, north-east Kazakhstan, near Lake Balkhash, in dimensions and shell outline, but the two valves of the Malayan form are less convex, the sinus deeper and the dorsal median fold more angular, and the costae less numerous. It differs from *S. carinatus* Rowley from the Lower Burlington Limestone of Missouri in having a more angular median fold, and more triangular cardinal area. The dimensions, costation, etc., of the two forms are, however, similar.

S. scrivenori also resembles specimens figured by Tschernyschew (1902, p. 533, pl. vi, fig. 9; pl. xii, fig. 3) as *S. marcoui* Waagen from the *Omphalotrochus* Kalk of the Ural Mountains and Timan, in shell outline and folding. The dorsal valve of the Malayan species is less convex, the linguiform extension of the pedicle valve shorter, and the costae less numerous. *S. scrivenori* is similarly distinguished from specimens of *S. marcoui* originally figured by Waagen (1883, p. 510, pl. xlvii) from the Lower Productus Limestone of the Salt Range.

Spirifer bollandensis Muir-Wood (1926, p. 241, pl. xvi, figs. 3, 4) from the Visean, C₂ subzone, of Clitheroe, Lancashire, has a similar shell outline, prominent median fold, and broad median sinus, but the fold is less angular and the linguiform extension of the pedicle valve is rounded. The British form which belongs to the *S. striatus* group attains considerably larger dimensions than *S. scrivenori*.

It is probable that the single specimen poorly figured in dorsal view by Yanishevsky (1918, pl. viii, fig. 4) as *S. duplicicostus* from the Lower Carboniferous of Ferghana, Russian Turkestan, should be identified as *S. scrivenori*. This form is unfortunately described in Russian only, but the specimen resembles the Malayan forms closely, both in contour, shell folding, and ornament. The Ferghana specimen is said to be from the Visean, probably = D₂ subzone.

S. scrivenori appears to be closely allied to *Spirifer lutugini* described by Rotai (1931, p. 130, pl. vii, figs. 1, 2) from the Visean, Beschevo Limestone, C₁^{5/2} (= C₁³ of the Geological Committee = D₃ subzone of England), from the Donetz Basin, Russia. Rotai states that

his species is near to *S. marcoui* Waagen, from which it differs in contour and in the development of concentric ornament. *S. scrivenori* differs from *S. lutugini* in its slightly narrower and more prominent median fold and slightly deeper sinus, and in the greater angularity of the linguiform extension of the pedicle valve. The costae in *S. lutugini* are finer and bifurcate more frequently than in *S. scrivenori*. The convexity of the valves and width of the cardinal area and the rounded cardinal extremities are similar in the two species.

It differs from the Malayan specimens described as *S. cf. condor* in its median fold, which increases in width rapidly in the ephebic stage and is more angular and prominent anteriorly. The median sinus is narrower and deeper, and the costae on the lateral slopes are more curved in *S. scrivenori* than in *S. cf. condor*.

Spirifer sp. (*striatus* group)

(Pl. viii, fig. 6)

One imperfect brachial valve [BB. 7817] with median fold and cardinal extremities not preserved resembles species of the *S. striatus* group in convexity of the valve, and in the costation. The median fold which was probably rounded, costate, and moderately prominent, is not preserved. From the growth-lines, which are only faintly seen, the hinge formed the widest part of the shell. The cardinal area is not preserved.

Each flank is ornamented by approximately eighteen even rounded costae, some of which bifurcate, giving a total of thirty costae near the anterior margin. There is no grouping or fasciculation of the costae which extend over the cardinal slopes. The growth-lines form a fine transverse ornament and there is no trace of the longitudinal striations found in species of the *S. striatus* group.

DIMENSIONS.—Length, 41 mm.; width (approx.), 65 mm.; thickness of brachial valve (approx.), 9 mm.

MATERIAL AND LOCALITY.—One specimen from Bukit Charas, loc. 5048, Pahang [BB. 7817].

REMARKS.—The costation of this specimen resembles that of *Spirifer liangchowensis* Chao (1929) from the Lower Carboniferous, Upper Visean, Choniukou formation of Kansu, north-west China. The median fold is, however, broader, the brachial valve more flattened, and the dimensions are greater in the Malayan form.

GENUS PHRICODOTHYRIS George, 1932

GENOTYPE *P. lucerna* George

Phricodothyris sp.

(Pl. ix, figs. 8, 9)

Ten imperfect and fragmentary specimens, ornamented by very numerous narrow concentric ribs, each bearing a row of fine spine-bases, have been referred to the genus *Phricodothyris*. The most perfect specimen [BB. 7776] showed the pedicle valve to be more convex than the brachial valve and the width to be greater than the length of the shell. The umbones are globose, and the rounded ventral umbo is incurved and in close proximity to the dorsal umbo. No median fold or sinus is developed, but the anterior commissure is incipiently uniplicate. The shell is ornamented by about twenty-four closely placed narrow concentric ribs in the space of 10 mm. These ribs are not prominent, and

each supports a single row of very minute spine-bases. Two other fragmentary specimens were similarly ornamented.

The remaining six specimens, of which **BB. 7777** is the most complete, have a rectimarginate anterior commissure, and are ornamented by eleven to sixteen ribs in the space of 10 mm. The ribs in these specimens are more angular and prominent, and the spines are less numerous and are double-barrelled as in species of *Phricodothyris*.

None of the specimens showed any median septum in the pedicle valve, but reduced apical plates were observed in one specimen.

DIMENSIONS.—Specimen No. **BB. 7776**: length, 16 mm.; width, 19.5 mm.; thickness, 11 mm.

MATERIAL AND LOCALITY.—Ten specimens, six of which are preserved in the British Museum (Nat. Hist.) and four duplicates, two from Bukit Tinggik and two from Bukit Sagu, in the collection of the Malayan Geological Survey. Of the British Museum specimens, four are from Bukit Sagu [**BB. 7776-8, 8039**] and two from Bukit Tinggik [**BB. 7779-80**].

REMARKS.—These specimens resemble Lower Carboniferous species of *Phricodothyris* which occur commonly in the Visean of Great Britain. The external form and ornament and lack of apical plates are comparable. The uniplicate anterior commissure and fine closely-placed ribs of specimen [**BB. 7776**] might be compared with *Phricodothyris periculosa* George from the D₂[B₂] subzone of Elbolton, Yorkshire, while the rectimarginate series represented by [**BB. 7777**], with fewer ribs, is nearer to *P. lineata* (Martin) from the D₂ subzone of Derbyshire. These specimens are referred to *Phricodothyris* rather than to *Squamularia* Gemmellaro. The genotype of *Squamularia* from the Permian of Sicily is said to have no apical plates and the shell, as figured by Gemmellaro (1899, p. 190, pl. xxxiii, figs. 38-45) is ornamented by a few widely spaced imbricating ribs, fringed with spines. The genus *Squamularia* is discussed by Dunbar and Condra (1932, p. 311) and several Upper Carboniferous species from Nebraska are referred to it. If these American forms are true *Squamularias*, one of the chief distinctions between it and *Phricodothyris* appears to be in the surface ornament which consists of terrace-like concentric ribs with two series of double-barrelled spines, both series having transverse carinae in the former genus. In *Phricodothyris*, according to George (1932, p. 528), the spines are double-barrelled and bear hooklets on either side which are inclined to the main spine, and resemble an anchor. Until material is available for the study of the genotype of *Squamularia* it seems preferable to refer Lower Carboniferous forms with or without reduced apical plates to *Phricodothyris*.

Reticularia lineata has been recorded from the Visean of Tian-shan by Gröber (1909), and Krenkel (1913); from the Visean of Shah Abdul Azim Mountains, south-east of Teheran (Rivière, 1934), and by Tolmachoff (1926) from the Tournaisian and Visean of the Kuznetzk coal-field, Altai, in the southern part of West Siberia.

GENUS RETICULARIA M'Coy, 1844

GENOTYPE *Terebratula imbricata* J. Sowerby

Reticularia imbricata (J. Sowerby)

(Pl. vi, figs. 5 a, b, 6)

1822. *Terebratula imbricata* J. Sowerby, p. 40, pl. cccxxiv, figs. 3, 4.

1932. *Reticularia imbricata* (Sowerby): George, p. 558, pl. xxxii, fig. 1 (pl. xxxi in explan. of plate).

Three imperfectly preserved specimens have the widely spaced concentric ribs and large spine-bases characteristic of *R. imbricata* (J. Sowerby), the type of which is from the

D₂ subzone of Yorkshire. The dimensions of the three specimens are similar, and it is probable that they are slightly immature forms. The most complete specimen [BB. 7770] is approximately circular in outline with valves almost equally convex. The cardinal area is obscure, but the hinge is considerably less than the greatest width of the shell, with the cardinal extremities subangular. No median fold or sinus is developed, but the anterior commissure is incipiently uniplicate. The ventral umbo is incurved and almost in contact with the dorsal umbo. The ornament consists of concentric lamellae set at an interval of about 2 mm. apart on the anterior part of the shell. The spine-bases are large and evenly arranged in rows, and extend across the ribs, giving the appearance of costation to the shell. Owing to decortication the spine-bases are poorly preserved, but one spine appeared to be double-barrelled, as in British examples.

Apical plates diverging at a low angle and a median septum could be seen through the test of the pedicle valve of the figured specimen.

DIMENSIONS.—Specimen No. BB. 7770: maximum length, 19 mm.; maximum width, 20 mm.; maximum thickness, 13.5 mm.; width of hinge, 11 mm.

MATERIAL AND LOCALITY.—Two specimens from Bukit Sagu [BB. 7770-1] and one from Bukit Tinggik, Pahang [BB. 7784].

REMARKS.—Although smaller in size than typical adult examples of *R. imbricata*, the Malayan specimens resemble them so closely in shape, folding, ornament, etc., that it seems advisable to refer them to Sowerby's species. *R. imbricata* occurs in the D₂ subzone of England, also in the C₂ and S knolls.

Reticularia imbricata was recorded, but not figured by Tolmachoff (1926) from the Tournaisian and Viséan of Kuznetzk coal-field, Altai, Siberia.

Reticularia cf. *alexandri* George

(Pl. vi, figs. 1 a-d)

cf. *Reticularia alexandri* George, 1932, p. 553, pl. xxxii, figs. 2 a-d.

Two imperfect specimens from Bukit Sagu [BB. 7774-5] in which half of the brachial and pedicle valve is preserved, resemble the species *R. alexandri* from the D₂ subzone of Scaleber Knoll, Yorkshire. The brachial valve is convex with prominent acute median fold, while the pedicle valve is posteriorly convex with a shallow median sulcus developed about 6 mm. below the umbo. The shell is transversely subpentagonal in outline with the width considerably greater than the length. The hinge is about two-thirds of the greatest width of the shell. The ventral median sinus increases in width and depth anteriorly and curves up to the slightly convex flanks. The linguiform extension is triangular in outline and tapers to a subacute extremity. The shell is much decorticated and exhibits faulting on a minute scale. It is difficult to see the details of the ornament, but rows of minute spine-bases set on low concentric ribs can be distinguished on some parts of the shell. It was not possible to see whether these spines are simple or double-barrelled. The concentric ribs are about 0.25 mm. apart. The umbo of the pedicle valve tapers to an acute extremity which is slightly incurved over the narrow triangular cardinal area. The two umbones are 2 mm. apart.

Apical plates and a median septum could be seen through the test in the umbo of one pedicle valve.

DIMENSIONS.—Specimen No. BB. 7774: length, 27.5 mm.; width (approx.), 46 mm.; thickness, 22 mm.

REMARKS.—The Malayan specimens resemble *R. alexandri* George in folding and in length and thickness of the shell, but the English specimens are only 30.5 mm. wide. The

linguiform extension in the British form tapers more rapidly, and more of the lateral slopes are seen in anterior view, also the cardinal angles are obtusely angular instead of rounded as in the Malayan form.

R. cf. alexandri is distinguished from *R. acutiloba* George (1932, p. 551, pl. xxxiv, fig. 2) and *R. lobata* Muir-Wood (1926, p. 242, pl. xvi, figs. 1, 2) from the British Carboniferous D_2 , S_2 , D_1 and C_2 subzones, by its less prominent fold and shallower median sinus, and by the non-development of lateral sulci on each side of the median fold. It differs also from *R. lobata* in its smaller dimensions and less convex valves, but resembles *R. acutiloba* in shell outline and dimensions.

R. cf. alexandri differs from *R. beschewiana* Rotai (1931, p. 133, pl. x, figs. 1 a-e) from the Visean, Beschevo Limestone, C_1^6 (= D_3 subzone of England), of the Donetz Basin, Russia, by its slightly smaller dimensions, less convex valves, more steeply sloping dorsal flanks, and narrower and more acutely tapering linguiform extension of the pedicle valve.

Yanishevsky (1918, p. 95, pl. vi, figs. 13 a, b) figured one specimen as *Reticularia elliptica* (Phill.) from the Visean of Ferghana, which although of smaller size appears to be comparable to the Malayan specimens in shell outline and folding.

The specimen figured by Löweneck (1932, p. 26, pl. i, figs. 3 a, b) as *Reticularia lobata* Muir-Wood from the Upper Visean of Basch-sugun, Tian-shan, is a broader form with less convex valves and a more sharply demarcated median fold.

Superfamily ROSTROSPIRACEA

Family ATHYRIDAE

GENUS CLEIOTHYRIDINA S. S. Buckman, 1906

GENOTYPE *Spirifer deroissii* Léveillé (= *Athyris royssii* Dav., partim)

Cleiothyridina sp.

Two specimens from Bukit Sagu [BB. 7782-3], one a fragment only of the pedicle valve, are identified as *Cleiothyridina* sp. The more complete specimen shows part of both valves, which are approximately circular in outline and biconvex without median fold or sinus. The ventral umbo is massive, incurved, and in contact with the brachial valve, and the elongate-oval foramen is well exposed. The shell is ornamented by numerous concentric ribs which are imperfectly preserved owing to decortication of the shell, and spine-bases forming a fringe-like covering to some of the ribs are faintly discernible. In the second specimen these rows of spines are preserved on the anterior part of the shell. Internal characters are unknown.

DIMENSIONS.—Specimen No. BB. 7782: length, 23.5 mm.; width (approx.), 24 mm.; thickness, 16.5 mm.

REMARKS.—The absence of median fold and sinus distinguish the Malayan specimen from examples of *C. roissii* (Léveillé) which occur commonly in the C_1 subzone of Tournai, and in the English and Irish Tournaisian. The Malayan form resembles, however, unnamed forms commonly identified as *C. royssii* (Davidson non Léveillé) which occur in the D_2 subzone of Derbyshire. These specimens are circular in outline, without fold and sinus with an incurved perforate umbo in contact with the brachial valve. The dimensions and ornament are similar to those of the Malayan specimen.

Superfamily TEREBRATULACEA

Family DIELASMATIDAE

GENUS DIELASMA King, 1859

GENOTYPE *Terebratulites elongatus* Schlotheim***Dielasma* cf. *attenuatum* (Martin)**(Pl. ix, figs. 1 *a*, *b*, 2)cf. *Conchyliolithus Anomites attenuatus?* Martin, 1809, p. 14.cf. *Dielasma attenuatum* (Martin) de Koninck, 1887, pl. 18, p. viii, figs. 2-22, 44-48.

One specimen from Bukit Sagu [BB. 7787] lacks the apex of the ventral umbo, but is elongate-oval in outline and resembles de Koninck's figures of *D. attenuatum* in form and contour. The brachial valve is posteriorly convex, but flattens in the later growth-stages. The pedicle valve is more convex than the brachial valve. No median fold or sinus is developed and the anterior commissure is incipiently uniplicate. The lateral commissure is deflected very slightly towards the pedicle valve, and the two valves meet at an acute angle along both anterior and lateral commissures. The beak-ridges are epithyrid and subangular. Other beak and internal characters are unknown.

A fragmentary specimen [BB. 7788] with the umbo preserved may belong to the same species, but is slightly narrower, and the posterior part of the brachial valve, the only part preserved, is more convex. The lateral contour, however, closely resembles that of de Koninck's specimen (pl. viii, fig. 46). The foramen is small and circular and the beak is slightly more erect than in the Belgian specimens.

DIMENSIONS.—Length, 22 mm.; width, 20 mm.; thickness, 9 mm.

LOCALITY AND MATERIAL.—Two specimens from Bukit Sagu [BB. 7787-8].

REMARKS.—De Koninck's specimens are all from the Visean (étage III) of Visé, Belgium. The dimensions of the Visean adult shells agree well with those of the Malayan specimens, and the slightly convex valves and acute angle of contact of the two valves are additional points of resemblance. This species was not figured by Martin, but de Koninck assumes his specimens to be identical with Martin's species described from Derbyshire.

In de Koninck's specimens the umbo is slightly incurved and the foramen small and circular. The beak-ridges are acute and epithyrid as in the Malayan specimen.

***Dielasma* sp.**

(Pl. ix, fig. 3)

Two detached pedicle valves are too imperfect for specific determination. The larger of the two is elongate-oval in outline, about 22 mm. long, 18 mm. wide, and 10.5 mm. thick, and moderately convex with no median sinus. The greatest width of the shell occurs near the anterior margin. The anterior commissure is not preserved, but the lateral commissure is ventrally bowed. The beak-ridges are scarcely defined, but appear to be epithyrid in position. The umbo is slightly incurved and truncated by a large rounded foramen. Growth-lines are rather prominent. The second specimen is crushed, but appears to show similar characters.

LOCALITY and MATERIAL.—Two specimens from Bukit Sagu [BB. 7785-6].

REMARKS.—These specimens resemble some young specimens of *D. hastata* (J. de C. Sow.) from the British Visean in their narrow elongate shell outline and large epithyrid foramen.

(2) Lower Carboniferous Species of Sungei Terapai

Order PROTREMATA

Superfamily DALMANELLACEA

Family SCHIZOPHORIIDAE

GENUS SCHIZOPHORIA King, 1850

Schizophoria sp.

(Pl. i, figs. 4, 5, 9)

This genus is represented by about twenty detached pedicle and brachial valves [BB. 7769, 7973-82], more than half of which are immature. Most of the specimens are poorly preserved as internal casts. The shell is wider than long with the brachial valve more convex than the pedicle valve. The anterior part of the brachial valve is depressed, but not sulcate, while a shallow sinus may be developed on the anterior part of the pedicle valve. The widest part of the shell occurs about midway between the hinge and the anterior margin.

In the pedicle valve the umbo is massive and slightly incurved. No cardinal area was preserved in any of the specimens. The shell is ornamented by fine costae (about thirty-four to forty in 10 mm. or four in 1 mm.), some of which are enlarged and bear minute spine-bases. The spines tend to be more numerous in the gerontic stage. In some specimens every fourth or fifth costa on the anterior part of the shell tends to be of slightly larger diameter than the intervening ones and to bear a spine-base. Bifurcation of the costae occurs frequently. Growth-lines are not conspicuous, but an occasional growth-lamella is developed. The dental lamellae are represented as slightly curved slits which diverge at an angle of about 45°, and extend for about 5 mm. from the umbo. A median septum about 6.5 mm. in length separates the muscle-scars, the details about which are unknown.

In the brachial valve the ornament is similar to that of the pedicle valve. The curving brachiopore plates diverge from the umbo at an angle of about 80°, and a narrow incision at the umbo of this valve represents the elongated cardinal process. One immature brachial valve [BB. 7974] showed the adductor muscle-scars which are separated by a short and narrow euseptoid.

DIMENSIONS.—Specimen No. BB. 7973, Brachial valve, maximum length, 19.5 mm.; maximum width, 27.4 mm.; maximum thickness, 3.5 mm. Specimen No. BB. 7975, Pedicle valve, maximum length, 17.5 mm.; maximum width, 22.5 mm.; maximum thickness, 3.2 mm.

REMARKS.—*Schizophoria* sp. differs from *Schizophoria resupinata* (Martin) from the Visean of Derbyshire by its smaller dimensions, less sinuate pedicle valve, and finer costation. In Martin's species there are from ten to twelve costae in 5 mm. and about three to four in 1 mm. These specimens differ from *Schizophoria mesoloba* (Yanishevsky) from Ferghana, and from Bukit Sagu and Bukit Tinggik, Malaya, by the non-development of a median sinus in the brachial valve, and by their coarser costae. The single specimen

described from Bukit Sagu as *Schizophoria* sp. has slightly finer costae (fifty in 10 mm.) than the Sungei Terapai forms.

Superfamily STROPHOMENACEA

Family STROPHOMENIDAE

GENUS *LEPTAENA* Dalman, 1828

GENOTYPE *Conchita rhomboidalis* Wilckens

***Leptaena* cf. *analoga* (Phillips)**

(Pl. i, figs. 6, 7)

cf. *Producta analoga* Phillips, 1836, p. 215, pl. vii, fig. 10.

cf. *Strophomena rhomboidalis* var. *analoga* (Phillips): Davidson, 1861, p. 119, pl. xxviii, figs. 1-6, 9-13.

This species is represented by six pedicle and two brachial valves, all imperfectly preserved. The brachial valves consist of fragments of the posterior portion which is flat and ornamented by fine longitudinal costae, bifurcating rather frequently, and crossed by narrow undulating concentric ribs which are faintly traceable across the visceral disk. A small bifid cardinal process could be seen in one specimen. The pedicle valve is slightly convex on the visceral disk and is then geniculated, forming a short trail which extends at an angle of 45° to the visceral disk. No median sinus is developed on the visceral disk, but the median part of the trail is depressed. The shell is quadrate in outline with sub-angular cardinal extremities and the hinge is approximately the widest part. The cardinal area is narrow. Delthyrium and deltidium are not preserved.

The pedicle valve is ornamented by fine longitudinal costae (fourteen to twenty in 10 mm. on middle of visceral disk), which increase by means of bifurcations. These are intersected by numerous irregular undulating ribs which are well developed near the hinge and on lateral slopes, but tend to flatten out on the front of the visceral disk. One or more of these ribs may bifurcate near the hinge-margin.

Decortication of the shell in two specimens revealed the short median ridge in the pedicle valve which does not extend to the umbo, and separates two narrow-elongate adductor scars. The latter are in contact on their lateral margins with the trigonal diductors.

DIMENSIONS.—Specimen No. **BB. 7904**, Brachial valve, length, 24.5 mm.; width, 32.5 mm. Specimen No. **BB. 7903**, Pedicle valve, length, 27.5 mm.; width, 38.2 mm.; thickness, 3.2 mm.

MATERIAL AND LOCALITY.—Eight detached valves from Sungei Terapai [**BB. 7900-6, 7949**].

REMARKS.—*Leptaena analoga* (Phill.) occurs commonly in the Tournaisian and Lower Viséan of Belgium, but in Great Britain it occurs more often in the Viséan, especially in the D₂ subzone of Yorkshire. In specimens of *L. analoga* there are fifteen or more prominent concentric rugae as compared with twelve to fifteen ill-defined ribs in the Malayan specimens. There are twenty to thirty costae in 10 mm. in Phillips's species as compared with fourteen to twenty in the Malayan shells.

Leptaena sinuata (non de Kon.) as figured by Demanet (1934, p. 74, pl. vi, figs. 6, 7), has coarser costation than *L. analoga*, and resembles the Malayan specimens in the more irregular rugae. The geniculated portion of the valve is, however, shorter in the Belgian specimens which are from the Viséan of Visé.

L. cf. analoga differs from *L. semibugensis* Nalivkin (1937, p. 136, pl. iii, fig. 9) from the Tournaisian, lower part of Kassin Beds, of Kazakhstan, central Asia, by the lack of a smooth area posteriorly, and by its more prominent concentric rugae. In *L. semibugensis* the rugae are said to be absent or faintly discernible, while the costae are said to be extremely fine.

Reed (1927, p. 42, pl. ix, fig. 4) figured a single pedicle valve from the Lower Carboniferous of Ta-shih-wo, Yunnan, where it occurs with a Visean fauna. In Reed's specimen the eleven to twelve concentric ribs are slightly more prominent on the centre of the visceral disk than in the Malayan form.

L. rhomboidalis var. *analoga* was recorded but not figured by Yanishevsky (1918, p. 17) from Ferghana, Turkestan; from the Visean of eastern Ferghana by Mouchkétov (1915); and from the Tournaisian and Visean of Kuznetzk coal-field, Altai, Siberia, by Tolmachoff (1926).

Leptaena analoga has also been figured by Frech (1916, pl. ii, fig. 3 d) from the Tournaisian of either Yerkopru, Taurus Range, in the south of Asia Minor, or from Arpatschai, Armenia. One of the forms figured (fig. 3 d) is fairly typical of this species. Mansuy (1913d, p. 31, pl. v, fig. 3) figured a comparable form from the Visean of Nong-po, Tran-ninh, Laos, Indo-China, as "*Plectambonites*" *rhomboidalis* var. *analoga*. This specimen is geniculated at the anterior end of the visceral disk and has acute cardinal angles. The ornament consists of about ten ribs traceable across the visceral disk and there are about eleven costae in 5 mm., as compared with ten to twelve costae in 10 mm. in the Malayan specimens.

L. analoga was also recorded from the Tournaisian, upper part of Kolaohuan, or Tangpakou Series of China, by Ting and Grabau (1934). These authors state that *Leptaena* does not occur in the Devonian of eastern Asia, and that it is a boreal form first appearing in the Kolaohuan of China and indicating a migration from European waters.

Meyer (1922) figured a large specimen as *Leptaena analoga* from the ?Lower Carboniferous of Djambi, Sumatra, where it is said to be associated with "*Spirifer*" *urii* and *Chonetes variolata*. The figured specimen (pl. i, fig. 3) from Sungi Landak is about twice the size of the Malayan specimens (7 cm. broad and 5 cm. long), with fine costae and about twenty concentric ribs crossing the front of the visceral disk, and appears to be a distinct species.

A larger specimen than the Malayan shells was also figured by Dun (1900, p. 74, pl. xxi, figs. 1-3) from the Lower Carboniferous, Tournaisian, of Clarence Town, New South Wales. This specimen had eleven better-defined ribs and slightly coarser costae than *L. cf. analoga* from Malaya.

Family CHONETIDAE

GENUS CHONETES Fischer von Waldheim, 1830

Chonetes sp.

(Pl. i, fig. 3; pl. ii, fig. 4)

This genus is represented by four imperfect internal casts of the pedicle valve from Sungei Terapai [BB. 7912-14, 7909]. In only one of these specimens can any trace of the ornament be seen, and no specific determination can be given. The largest of the three specimens is 9.5 mm. long, 15 mm. wide, and 5 mm. thick, with a highly convex shell without any median sinus. The hinge forms the widest part of the shell. The cardinal extremities are imperfectly preserved, but appear to be subangular, and the shell tapers

gently laterally. The ears are not well demarcated from the visceral disk. The lateral contour is semicircular and the flanks slope gently up to the arched venter. No ornament was visible in this specimen. A short median septum is seen extending for about 5 mm. from the umbo and separating the broad trigonal muscle-scars, but the latter could not be separated into diductor and adductor scars.

In a smaller specimen traces of the costation could be seen at the anterior margin where there are thirty-six costae in 10 mm. No spine-bases or growth-lines could be distinguished in any of the specimens.

Family PRODUCTIDAE

GENUS DICTYOCLOSTUS Muir-Wood, 1929

Dictyoclostus cf. *parvus* (Meek & Worthen)

(Pl. ii, fig. 11)

cf. *Productus parvus* Meek & Worthen, 1861, p. 450.

cf. *Productus parvus* Meek & Worthen, 1866, p. 297, pl. xxiii, figs. 4 a-e.

One pedicle valve from Sungei Terapai [BB. 7907], lacking the greater part of the visceral disk, is ornamented by fine longitudinal costae bearing numerous spine-bases. The shell is 17.5 mm. long and 18.5 mm. wide, with well-developed trail and steep flanks. No median sinus is developed. The ornament consists of very fine costae (twenty-four costae in 10 mm. on middle of trail) which rarely bifurcate. The spine-bases consist of a row extending up each flank and a group on the ears, in addition to scattered spine-bases springing from the summit of the costae on the trail. One or two of these spine-bases may be of larger diameter than the others, and two costae may unite above them, and bifurcate anteriorly to them. Fine ribs are seen at the anterior end of the visceral disk, causing slight reticulation at the point of intersection with the costae.

Internal characters are unknown.

REMARKS.—The Malayan specimen resembles *D. parvus* (Meek & Worthen) from the Upper Mississippian of Chester, Illinois, U.S.A., in its dimensions, lack of median sinus, fine costation (four costae in 2 mm.) and scattered spines on trail on summit of costae, also in group on ears and in row on flanks. The type of ornament resembles that of *D. muricatus* (Phill.) from the British Viséan, but the dimensions of the Malayan specimen are considerably smaller, and the costae finer than in Phillips's species. No comparable form is described by Chao (1927) from China.

GENUS ECHINOCONCHUS Weller, 1914

Echinoconchus elegans (M'Coy)

(Pl. i, figs. 1, 2)

1844. *Producta elegans* M'Coy, p. 108, pl. xviii, fig. 13.

1861. *Productus punctatus* var. ? *elegans* M'Coy: Davidson, p. 173, pl. xlv, fig. 15.

1897. *Productus punctatus* var. *elegans* M'Coy: Loczy, p. 108, pl. vi, figs. 4, 4 a, b.

1911. *Productus elegans* M'Coy: Frech, in Richthofen, p. 74, pl. xii, fig. 3.

1914. *Pustula elegans* (M'Coy) Thomas, p. 292, pl. xvii, figs. 1-4.

1918. *Productus elegans* M'Coy: Yanishevsky, p. 46, pl. viii, figs. 13, 14.

1924. *Productus elegans* M'Coy: Hayasaka, p. 32, pl. v, fig. 9.

Two small brachial valves and one pedicle valve from Sungei Terapai [BB. 7909-11] ornamented by flattened concentric bands bearing two rows of spine-bases resemble

E. elegans (M'Coy). The shell is approximately circular in outline and the brachial valve, seen in reverse, is only slightly convex. The umbonal region is, however, more convex than the remainder of the shell. The hinge is slightly less than the widest part of the shell and the cardinal angles are acute. The shell is ornamented by ten to twelve obtusely angular concentric bands, separated by narrow, smooth depressions. The concentric bands narrow towards the lateral slopes and are ornamented by a major series of spine-bases posteriorly placed, and one or two rows of very fine spine-bases which are rarely preserved, and are anterior to the major spines. In the umbonal region the bands are less well defined and spines are more irregularly arranged. Internal characters are unknown.

DIMENSIONS.—Specimen No. **BB. 7911**. Length, 13.5 mm.; width, 15.5 mm.; hinge, 13.5 mm. Specimen **BB. 7909**. Length, 11.5 mm.; width, 13 mm.

REMARKS.—*E. elegans* occurs in the C₂, S, and D zones of Great Britain and Ireland. The Malayan forms have similar ornament, but are slightly larger than the average British specimens. *E. elegans* is figured by Chao (1927, p. 64, pl. vi, figs. 1–6) from the Upper Visean, Choniukou Limestone of north-west Kansu, China, where it is a common species. The Chinese specimens also attain larger dimensions than the British forms, and have less numerous concentric bands (six in 15 mm.). These, however, bear two series of spine-bases, as in M'Coy's type.

A similar form was figured by Frech (1911, p. 74, pl. xii, fig. 3) as *Productus punctatus* from the upper part of the Lower Carboniferous of Itshoufu, Shantung, China, while Yanishevsky (1918, p. 46, pl. viii, figs. 13, 14) figured a single specimen ornamented by about twelve spinose concentric bands from the Visean of Ferghana, Turkestan.

Hayasaka (1924) also figured this species from the Lower Carboniferous of Omi-mura, Echigo, west Japan; and it was recorded by Gröber (1909, p. 380) from the Visean of Tian-shan, and by Krenkel (1913, p. 16) from Basch-sugun, north-east of Kashgar, Tian-shan.

GENUS *PRODUCTINA* Sutton, 1938

1928. *Thomasia* Fredericks (non Poche, 1908), pp. 783, 790 (genotype *Productus margaritaceus* Phillips).
 1931. *Thomasina* Paeckelmann (non Newstead & Carter, 1911), pp. 75, 181.
 1938. *Productina* Sutton, 1938, p. 551.
 1942. *Thomasella* Paul (non Fredericks, 1928), p. 126.

GENOTYPE *Productus sampsoni* Weller

REMARKS.—The generic names *Thomasia*, *Thomasella*, and *Thomasina* are preoccupied, but it seems probable that the genus *Productina* proposed by Sutton for *Productus sampsoni* Weller and *Productus parvulus* Winchell, should also include the *Productus margaritaceus* group. From Weller's description of *P. sampsoni* the shell characters, contour, and type of ornament are similar to those of *P. margaritaceus* although the American forms are of considerably smaller size. The concentric lamellar ornament characteristic of *P. margaritaceus* also occurs in *P. sampsoni*, although it is said to be absent in Sutton's diagnosis.

P. sampsoni occurs in the Lower Mississippian, Chouteau Limestone of U.S.A.

Productina cf. *margaritacea* (Phillips)

(Pl. i, fig. 8)

- cf. *Producta margaritacea* Phillips, 1836, p. 215, pl. viii, fig. 8.
 cf. *Productus margaritaceus* Phillips: Davidson, 1861, p. 159, pl. xlv, figs. 5–8.

One imperfect pedicle valve from Sungei Terapai [**BB. 7908**] is referred to the genus *Productina* on account of its shell outline, ornament, and disposition of spines. The shell is 17 mm. long, 21 mm. wide, and 5 mm. thick, with the hinge forming the widest

part of the shell. The shell is evenly curved posteriorly-anteriorly, and lacks any geniculation. The flanks are gently sloping and arched up to the rounded venter. No median sinus is developed. The ears are rather large and flattened and are separated from the visceral disk by a shallow sulcus. The umbo is much incurved and the apex could not be observed. The ornament, which is imperfectly preserved on the posterior part of the shell, consists of rounded costae of irregular width, due to fairly numerous bifurcations. The intervening sulci are about half the width of the costae. There are eleven costae in 10 mm. near the anterior margin. No ribs are developed, but growth-lines and one or two lamellae marking growth-halts could be distinguished. One row of spine-bases could be seen extending across the ears at an angle of 30° to the hinge-margin. The actual cardinal margin is imperfectly preserved and no rows of spine-bases could therefore be seen near it.

REMARKS.—This specimen resembles *Productina margaritacea* (Phillips) in its approximately circular shell outline, semicircular profile, large flattened ears, and in absence of ribs. It differs from adult shells of the British species, however, in its smaller dimensions, less convex shell, finer costation, and less prominent growth-halts. If the costae of adult specimens, similar in size with Phillips's type from Florence Court, Fermanagh, Ireland, are measured at a distance of 15 mm. from the umbo they will be found comparable with those of the Malayan specimen (eleven in 10 mm.). A row of spines on the ears at an angle of 30° to the hinge-margin is also seen in specimens of *P. margaritacea*. *P. margaritacea* occurs in the D_2 subzone of Great Britain.

Rotai (1931, p. 55, pl. iii, fig. 4) figured a specimen of *Productus margaritaceus* from the Lower Carboniferous, Visean, Beschevo Limestone of the Donetz Basin, Russia. This specimen is larger than the Malayan form, but agrees with it in costation and shell outline. The Donetz specimen is from the C_1^2 horizon = C_1^3 of the Geological Committee, which is said to be equivalent to the D_3 subzone of England.

Yanishevsky (1918, p. 45, pl. viii, fig. 38) figured a small form as *Productus cf. margaritaceus* from the Visean of Ferghana. This specimen is 16 mm. long and 22 mm. wide, and resembles *P. margaritacea* in contour, but is more finely costate at the anterior margin owing to numerous bifurcations of the costae.

Thomasina cf. margaritaceus was recorded but not figured by Nalivkin (1937) from the Ishim Beds, lower part of the Visean of Kazakhstan, central Asia.

Order TELOTREMATA

Superfamily SPIRIFERACEA

Family SPIRIFERINIDAE

GENUS PUNCTOSPIRIFER North, 1920

- 1920. *Punctospirifer* North, p. 212.
- 1927. *Punctospirifer* Muir-Wood, p. 289.
- 1930. *Punctospirifer* King, p. 124.
- 1931. *Punctospirifer* Paeckelmann, p. 51.
- 1932. *Punctospirifer* Dunbar & Condra, p. 350.
- 1935. *Punctospirifer* H. D. Thomas, p. 203.
- 1941. *Punctospirifer* Sokolskaia, p. 50.

SYN. *Spiriferina* (in part.) auctt.

GENOTYPE *P. scabricostus* North from the Lower Carboniferous, *Seminula* zone of Ravenstonedale District, Westmorland

Species (at present recognized): British Visean.—*P. scabricostus* mut. *ashfellensis* North, *Seminula* zone; *P. scabricostus* mut. *redesdalensis* North, D_1 subzone of Redesdale,

Northumberland; *P. northi* Muir-Wood, D₃ shales above Upper Fell Top Limestone, Northumberland.

Transition Beds between Devonian and Carboniferous.—Malevka Beds; and Tournaisian.—Tschernyschino Beds of Moscow Basin.—*Punctospirifer malevkaensis* Sok., *P. ? latus* Sok., *P. multicostatus* Sok., *P. partitus* (Portlock).

Mississippian.—*P. solidorostris* (White), *P. subellipticus* (McChesney), *P. subtextus* (White), all from the Kinderhook Lower Mississippian; *P. transversus* (McChesney) from the Upper Mississippian, Chester Group; *P. verneuili* (Bell), Windsor Series of Nova Scotia=Visean.

Pennsylvanian.—*Punctospirifer kentuckyensis* (Shumard), Missouri.

Permian.—*P. pulcher* (Meek), Mid. Permian, Nevada, and Wyoming; ? *P. billingsi* (Shumard), Texas; ? *P. wimani* Stepanov, Spitsbergen.

REMARKS.—The distribution and range of this genus is still imperfectly known as it has only been recently recognized in Russia and has not been recorded elsewhere in Europe. It has not been previously recorded from Asia, nor have any comparable forms been figured up to the present. None of Waagen's specimens from the Productus Limestone of the Salt Range can be referred to *Punctospirifer*, and Chao does not mention *Punctospirifer* among the Spiriferids of China in 1929.

The genus ranges from the Malevka Beds of the Moscow Basin, which are said by Sokolskaia (1940) to be Devonian-Carboniferous Passage Beds [? = Etroeungt Beds], to the Permian of North America, and possibly the Arctic Regions, but in Great Britain it is represented so far by the three described Visean species of Westmorland and Northumberland. An undescribed species has also been observed in the D₂ subzone of Derbyshire, and Mitchell and Stubblefield (1941, p. 207) record *Punctospirifer* sp. from C₂—S₁ beds of Breedon Cloud, Leicestershire.

Some of the species recorded from the Visean of central Asia as "*Spiriferina*" *laminosa* and *Spiriferina* sp. probably will have to be referred to *Punctospirifer*, especially the punctate form figured by Löweneck (1932, p. 74, pl. iii, fig. 7) from Utsch-turfan, Tianshan. Andronov (1937, p. 219) recorded *S. laminosa* from the Visean (=D₂ subzone) of Kazakhstan, near the Ishim River, and the form intended is probably a *Punctospirifer*.

A species of *Punctospirifer* is figured by Rotai (1931, p. 93, pl. x, fig. 14) as *Spiriferina* aff. *saemensis* Weller from the Visean, C₁⁷ (=D₁⁵ of the Geological Committee and =D₃ subzone of England), from the Donetz Basin, Russia.

From information so far available, therefore, *Punctospirifer* occurs in the Tournaisian and Visean of Europe and Visean of Asia, and in the Lower Mississippian, Kinderhook=Tournaisian, and Upper Mississippian of North America. In the Tournaisian of Europe *Punctospirifer* is usually replaced by the impunctate genus *Tylothyris*, and many Tournaisian species such as *Spiriferina mollerii*, and *S. peracuta* de Koninck, from Belgium, in addition to *S. laminosa* M'Coy from Z₂ and C₁ of Ireland, and the South-west Province of England, should be referred to *Tylothyris*. These species have prominent concentric growth-lines and are ornamented by twelve or more costae on the lateral slopes as compared with six to twelve costae on each lateral slope of *Punctospirifer*.

The principal distinguishing characters of *Punctospirifer* are (1) V-shaped jugum; (2) hinge-line approximately equal to the greatest width of the shell, and width of shell usually equal to twice the length; (3) broad, rounded, median fold and wide shallow sinus, and six to twelve narrow rounded plications on each lateral slope; (4) fine evenly developed lamellose ornament; (5) moderately high flattened or concave cardinal area with angular margins sharply defining it from the lateral slopes.

It resembles *Spiriferellina* in having a punctate shell, but differs from it in having more numerous and less angular plications on the lateral slopes, and in having a more flattened, broader median fold, and shallower sinus. In *Spiriferellina* the cardinal area is

not sharply demarcated from the lateral slopes. The concentric lamellose ornament is more prominent in *Punctospirifer*.

There are also considerable differences in the internal structure of the two genera.

***Punctospirifer pahangensis* sp. nov.**

(Pl. i, fig. 9; pl. ii, figs. 5-10, 12)

DIAGNOSIS.—*Punctospirifer*, about 10 mm. long, 20 mm. wide, and 8 mm. thick, hinge forming widest part of shell, cardinal extremities subrounded or acute. Height of cardinal area equals one-third of length, slightly concave. Umbo small, acute. Delthyrial angle 20° . Ornamented by twelve to fourteen simple costae separated by sulci about half their width. Median dorsal fold low and rounded, median sinus shallow. Concentric lamellose ornament prominent. Apical angle 80° .

TYPE-SPECIMEN.—Holotype, brachial valve [BB. 7946]. Paratypes, brachial valve [BB. 7971]; pedicle valve [BB. 7942]; two valves (in anterior view only) [BB. 7947].

MATERIAL AND LOCALITY.—Numerous detached pedicle and brachial valves and one fragmentary specimen with valves united, from Sungei Terapai, Pahang [BB. 7939-48, 7950-67, 7971, and 7974]. Twenty specimens in the Malayan Geological Survey Collection.

DIMENSIONS.—Holotype, maximum length, 9.5 mm.; maximum width, 15 mm. Paratype [BB. 7971], maximum length, 10 mm.; maximum width, 20 mm.

DESCRIPTION.—The shell is spiriferoid in outline with the width approximately twice the length, and the greatest width occurs at or immediately below the cardinal extremities. These may be acute in the more alate varieties, or subrounded. Both valves are slightly convex with well-defined median fold and sinus. The dorsal fold increases slightly in width anteriorly, but is always rounded, not prominent, and is separated from the lateral slopes by a narrow deep sulcus. The median sinus is shallow, rounded, and separated from the lateral slopes by two prominent costae. The linguiform extension of the pedicle valve is short and rounded. The ventral umbo is acute, tapering, and suberect. The cardinal area seen in four specimens is well demarcated from the lateral slopes and is slightly concave, the height being equal to about one-third of its length. The delthyrium is bounded by the delthyrial supporting plates, but the delthyrial plate was not exposed. The delthyrial angle is 20° .

The ornament consists of six to seven narrow rounded non-bifurcating costae on each lateral slope. These costae are slightly curved, and radiate out from the cardinal slopes, increasing slightly in width anteriorly, but never attaining more than one-quarter of the width of the median fold. The sulci separating the costae are about half the width of the costae. The costae near the cardinal angles are considerably narrower, and less prominent than those medianly situated. The ornament of the pedicle valve is similar, but the two costae bounding the median sinus tend to be the most prominent. As most of the specimens are decorticated the ornament of concentric lamellae is rarely well seen except on impressions. The lamellae are closely spaced and extend across costae and intervening sulci, and form the only ornament of the fold and sinus.

INTERNAL CHARACTERS.—No trace of jugum or spirals could be seen in any specimen. A median septum is developed in both dorsal and pedicle valves. The dorsal septum is approximately 5 mm. in length in a brachial valve 10 mm. long. In the ventral valve the delthyrial supporting plates diverge at an angle of 20° , while a median septum extends about 4.5 mm. from the umbo.

REMARKS.—*P. pahangensis* differs from *Spiriferina cambodgiensis* Mansuy (1914b, p. 24, pl. iii, figs. 2 a-i) [*?=Punctospirifer*] from the Calcaires à *Productus* [Lower Permian] of Cambodia by the lack of a division in the median fold and of a costa in the median sinus in the ventral valve. It is similarly distinguished from specimens figured by Tolmachoff

(1931, p. 553, pl. vii, figs. 27, 28) as *Spiriferina partita* (Portlock) from the Kuznetzk Basin. These specimens otherwise resemble the Malayan shells in dimensions and shell outline, and the ornament of the lateral slopes is similar. The exact horizon of these specimens at Kuznetzk is uncertain since Upper Tournaisian forms are here mixed with Visean species. A second species of *Punctospirifer* also occurs here of smaller dimensions than *P. pahangensis* and with seven costae on each lateral slope.

Another comparable form but with a medianly divided dorsal fold and a costa in the ventral sinus is figured by Gröber as *Spiriferina cristata* (1909, pl. iii, fig. 6) from the Visean of the Chonochai Valley, central Tian-shan. This specimen has seven costae on each lateral slope, but is otherwise similar in shell outline and ornament.

In dimensions and ornament *P. pahangensis* closely resembles *P. scabricostus* mut. *redesdalensis* from the D₁ subzone of Redesdale, Northumberland, although it has fewer costae on the lateral slopes, six to seven instead of seven to ten in the British species. The cardinal area in the Redesdale form is not so elevated as in *P. pahangensis*. The Malayan specimens differ from the earlier mutation *P. scabricostus* mut. *ashfellensis* from the S₁ subzone of Westmorland by their slightly smaller dimensions, less convex valves, and less prominent median fold. The height of the cardinal area is similar in the two species, though in *P. pahangensis* it is less concave.

It differs from *P. kentuckyensis* (Shumard) from the Pennsylvanian of U.S.A. by its less alate outline and less numerous costae. In this species a costa is also developed in the median sinus and a sulcus in the median fold. It is similarly distinguished from *P. transversus* (Weller, 1914, pl. xxxv, figs. 41-9) from the Upper Mississippian, Chester Group of Illinois. This species is more transverse than *P. pahangensis* and has more numerous costae.

The specimens figured by Rotai (1931, p. 93, pl. x, fig. 14) as *Spiriferina* [= *Punctospirifer*] aff. *salemensis* Weller from the Visean, C₁ (=D₃ subzone) of the Donetz Basin, differs from *P. pahangensis* in its slightly larger dimensions, more convex valves, and fewer and broader costae (five to six) on the lateral slopes. Weller's species *S. salemensis*, described from the Middle Mississippian of Indiana, belongs to the genus *Spiriferellina*.

Sokolskaia (1941) figured four species of *Punctospirifer* from Devonian-Carboniferous passage-beds and the Lower Carboniferous [Tournaisian] of the Moscow Basin.—*P. malevkaensis* sp. nov., *P. ? latus* sp. nov., *P. multicosatus* sp. nov., and *P. partitus*. None of these is identical with *P. pahangensis*, since with the exception of *P. ? latus* they are all of smaller size. The shells depicted as *P. partitus* (Portlock) differ from *P. pahangensis* in having more prominent costae, a more convex shell, and in the development of a median costa in the sinus of the pedicle valve. The costae of *P. multicosatus* are less prominent and more numerous than in *P. pahangensis*. *P. malevkaensis* is a much smaller shell, although in general form and ornament it is similar to the Malayan form.

Superfamily ROSTROSPIRACEA

Family RHYNCHOSPIRINIDAE

GENUS HUSTEDIA Hall & Clark, 1894

GENOTYPE *Terebratula mormoni* Marcou

Hustedia cf. **radialis** (Phillips)

(Pl. ii, figs. 1-3, 12)

cf. *Terebratula radialis* Phillips, 1836, p. 223, pl. xii, figs. 40, 41.

cf. *Retzia radialis* (Phillips): Davidson, 1861, p. 87, pl. xvii, figs. 19-21.

cf. *Retzia radialis* (Phillips): Davidson, 1863, p. 218, pl. li, figs. 4-9.

This species is represented by about twenty-six detached pedicle and brachial valves which have a finely punctate shell. Some of the specimens are preserved as internal casts

or as impressions. Both valves are moderately convex with a narrow median sulcus in the pedicle valve, but no median fold in the brachial valve. The shell is approximately circular in outline with the greatest width about midway between the anterior and posterior extremities. Small flattened ears are developed in the brachial valve. The umbo is small, tapering, and suberect, with a small circular foramen. The fused deltidial plates characteristic of this genus could not be seen owing to the pedicle valve always being preserved in ventral view. The anterior commissure is plane. The ornament consists of about sixteen to eighteen simple, subangular costae radiating out from the umbo and separated by sulci, which are equal to or half the width of the costae. In the internal casts these sulci appear wider and the costae narrower than in specimens having the outer shell preserved. The median costa in the brachial valve is usually slightly broader anteriorly than those on the lateral slopes.

Owing to the state of preservation of the specimens little could be ascertained about the internal characters. A short median septum about 2 mm. in length is present in the brachial valve. No muscle-scars could be distinguished in either valve and no dental lamellae are developed in the pedicle valve.

DIMENSIONS.—Specimen No. **BB. 7915**, Pedicle valve, length, 10.5 mm.; width, 10 mm.; thickness, 2.5 mm. Specimen No. **BB. 7916**, Brachial valve, length, 8.5 mm.; width, 9 mm.; thickness, 2.5 mm.

MATERIAL AND LOCALITY.—About twenty-six detached pedicle and brachial valves from Sungei Terapai [**BB. 7915-34, 7947**]. Four specimens in the Malayan Geological Survey Collection.

REMARKS.—These specimens resemble Phillips's species *H. radialis* in dimensions, shell outline, absence of median fold, and sinus. The number of costae in *H. radialis* is variable, but there are as a rule sixteen to nineteen costae which radiate out from the umbo, the median dorsal costa being enlarged as in the Malayan forms. In the British species the umbo tapers rapidly and is truncated by a small circular foramen below which the deltidial plates are fused together and appear as one plate. On each side of the umbo of the brachial valve the shell is produced into a small ear, as in the Malayan species. Phillips's specimen is from Bolland, but comparable forms occur in the D₂ subzone of Settle, Yorkshire, and Wetton and Narrowdale, Staffordshire.

The Malayan specimens differ from *H. mormoni* (Marcou), the genotype of *Hustedia* from the Upper Carboniferous of U.S.A., by their more circular shell outline, slightly larger dimensions and more numerous costae (sixteen to eighteen instead of ten to twelve in *H. mormoni*). In general shell characters and type of ornament, however, *H. cf. radialis* shows a strong resemblance to the American species. It differs from *H. grandicosta* (Dav.), as figured by Waagen (1883, p. 491, pl. xxxiv, figs. 6-12), from the Upper Productus Limestone (Upper Permian) of the Salt Range, India, by its considerably finer ornament.

Hustedia remota (Eichwald) figured by Mansuy (1914b, p. 25, pl. iii, figs. 4-6) from the Calcaires à *Productus* ([Lower Permian] of Cambodia, is a slightly smaller shell which is ornamented by ten to twelve rather prominent rounded costae, instead of the sixteen to eighteen costae of the Malayan form. This finer costation also distinguishes *H. cf. radialis* from *H. nasuta* and *H. pelargonium* Merla (1934, pl. xx, figs. 8-15) from the Uralian of Rimu, Caracorum, Kashmir.

Yanishevsky (1915, p. 52, pl. iv, fig. 11) figured two small imperfectly preserved specimens as *H. radialis* from the Visean, near Tomsk, Siberia. These specimens lack the median fold and sinus, but are ornamented by fewer (twelve) costae. Two specimens of similar dimensions as the Malayan forms, but with slightly coarser costae, were figured by the same author as *H. aff. radialis* from the Visean of Ferghana, Russian Turkestan (Yanishevsky, 1918, p. 110, pl. vi, figs. 11, 12).

A similar form is figured by Loczy (1897, pl. ii, figs. 13, 13 *a*, *b*) as *Eumetria* cf. *grandicosta* (Dav.) from the Lower Carboniferous [Visean] of Kansu, China. This specimen has detached valves, without median fold or sinus, which are ornamented by twelve to fourteen costae.

De Verneuil (1845, pl. x, figs. 9 *a*, *b*) described and figured a smaller specimen with twelve to fourteen costae as *Terebratula radialis*, which appears to be comparable with *H. cf. radialis*. It occurs at Zaráisk, in the government of Riazan, Russia.

The specimens of *H. radialis* figured by de Koninck from the Visean of Belgium in 1887 (p. 94, pl. xxii, figs. 16-19) are more elongated and more coarsely costate than the Malayan specimens. *H. multiplicata* de Koninck (op. cit., p. 95, pl. xxii, figs. 20-4) from the Tournaisian, near Tournai, appears to be a smaller shell with eighteen to twenty costae, but the valves are more convex; and there is no median sinus or enlargement of the dorsal median costa.

This species is referred to the genus *Hustedia*, on account of its umbo tapering to an acute extremity and truncated by a circular foramen, its non-bifurcating costae, the actual costation resembling that occurring in other species of *Hustedia*, the development of a median septum in the brachial valve, and its punctate shell.

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IX. APPENDIX

LEPIDODENDROID REMAINS FROM MALAYA

By W. N. EDWARDS

(Pl. X, figs. 1-3; Pl. XVII)

Plant remains, already briefly mentioned by Willbourn (1940, p. 28), were discovered by Mr. F. H. Fitch about half a mile below the locality in the Sungei Terapai, Pahang, which yielded the marine fauna, and almost at the same stratigraphical horizon. The fragmentary impressions, in a white micaceous sandy shale, retain little trace of carbonaceous material and are sometimes represented by a limonite stain.¹ Most of the plant fragments are decayed debris of wood or stems, evidently transported for some distance, and the presence among them of a crinoid ossicle indicates that the deposit was marine and confirms its contemporaneity with the nearby trilobite-bearing beds.

The few plant fossils which retain any recognizable features are all lepidodendroid, and indeed all might conceivably belong to one and the same species, though this cannot be definitely asserted. The two best specimens (pl. x, figs. 1, 2) are somewhat obscure impressions of twigs showing worn leaf-bases, which I regard as probably belonging to the genus *Lepidodendron*, using the name in a wide sense, though since the leaf-cushions show no details accurate generic or specific identification is impossible. With such imperfect fragments, a possible relationship to the Upper Devonian and Lower Carboniferous genus *Lepidodendropsis* cannot be entirely excluded. They are, however, undoubtedly reminiscent of a number of Lower Carboniferous species referred to *Lepidodendron*, but seem to be distinct from the Chinese Lower Carboniferous species *L. leeianum* Gothan and Sze (1933), and also from *L. mirabile* which has been recorded from China.

Three specimens, of which pl. x, fig. 3, represents the best, are decorticated lepidodendroid stems; the superficial resemblance of such specimens to ribbed Calamite stems should be particularly noted, for it might well deceive collectors unfamiliar with this decorticated state of lepidodendroid axes (cf. Sze's remarks on the possible occurrence of *Asterocalamites* in China, 1936a, p. 168). A somewhat similar specimen from the Lower Carboniferous of Yunnan has been figured by Halle (1927, pl. i, fig. 4; *Lepidodendron* sp.). One specimen (V. 26807) shows several linear-lanceolate impressions, one of them with a faint impression of a midrib, which might be lepidodendroid leaves; and there are two or three impressions (e.g. pl. x, fig. 1, lower half) of a *Stigmaria* (the underground axis of several lepidodendroid genera). Although very fragmentary, this *Stigmaria* bears some resemblance to "*Caragandites rugosus*" Zalesky (1933) from the Lower Carboniferous of Karaganda (pl. xvii, no. 64), which, as far as one can judge from his illustration, is probably a stigmarian axis.

In view of the indeterminate nature of these fossils, it would be unprofitable to pursue doubtful comparisons with plants from other regions. The age of the beds must depend on other evidence: since the animal remains suggest a Lower Carboniferous (Visean) age one can but say that the plants do not conflict with this. As a pendant to Dr. Muir-Wood's work on the palaeogeography of Asia in Visean times, however, a brief review of some Asiatic records of Lower Carboniferous plants may be of interest. The principal localities are noted on the map (pl. xvii); their exact age is frequently in doubt. Many of the known Lower Carboniferous land floras, especially in Europe, are of Visean age, and the distinguishing floral characteristics of the Tournaisian have scarcely yet been apprehended; it is therefore extremely unlikely that a few battered plant fragments could ever by themselves settle the age question conclusively. Where worn lepidodendroids only are found, the beds are often coastal or marine, as at Sungei Terapai; where there are longer

¹ Mr. E. S. Willbourn informs me that the white micaceous sandy shale is merely the weathered rock exposed on the surface; its unweathered equivalent is very different in appearance, being a black graphitic shale. Specimens have not yet been obtained from the unweathered rock.

floral lists with frond impressions, land (including freshwater and estuarine) conditions are indicated. Hirmer's review of Carboniferous floras (1939) has so far covered only the Lower Carboniferous of Europe and America; for Australia Walkom's papers should be consulted (1928, 1934, 1938). The Lower Carboniferous floras of Asia have only recently attracted much attention from palaeobotanists, owing partly to their comparative paucity, and partly to the very great importance of the later Palaeozoic.

Useful accounts of the coal basins of the U.S.S.R. have been published by Polutoff (1935) and by Prigorovsky (1937), while Jongmans' review (1939) of the Carboniferous and Permian Floras of the U.S.S.R. and East Asia admirably summarizes the scattered literature and includes critical discussions of various Lower Carboniferous plants.

CHINA

1. Yunnan

From three localities in the Chanyi district Halle (1927) recorded *Lepidodendron* sp. and lepidodendroid fragments, evidently of Lower Carboniferous age and associated with marine strata containing *Productus giganteus*. At four other localities Halle (1936) recorded lepidodendroid fragments and "indeterminable lepidophytes", which he thought were either Upper Devonian or Lower Carboniferous; for details of all these localities see the explanation of the map on pl. xvii (nos. 7, 56, and 57). Whatever the exact age, there is here an obvious parallel with the Sungei Terapai beds.

2. Kwangsi

The record of the occurrence of *Rhacopteris*, the most characteristic Lower Carboniferous frond genus, at Hsi-Wan (pl. xvii, no. 58; Sze, 1936a) has subsequently proved to be erroneous (Sze, 1938).

3. Kiangsu

A more extensive flora was developed in this province, mainly apparently in the region of Lake Taihu and south-east of Nanking; I have been unable to trace on any available map all the numerous localities mentioned by Gothan and Sze (1933); Gothan (1933); and Sze (1936), and they are represented by nos. 59 and 60 on pl. xvii. According to Sze the Wutung quartzite in which the plants are found is widely spread in eastern China, especially in Kiangsu. Gothan has suggested that the flora may be Tournaisian; if so, an encroachment of the sea may have followed later, for there are marine Visean beds near Nanking (pl. xvii, no. 12). The floral list includes several lepidodendroids (cones, leaves, and stigmarian axes, as well as four or five types of stem), two species of *Sphenophyllum* and two sphenopterids.

INDIA

The only known Lower Carboniferous plants are from the Po Series of Spiti (pl. xvii, no. 61). From the Thabo stage Gothan and Sahni (1937) record *Rhacopteris ovata*, *Sphenopteris (Rhodea)* sp., and *Sphenopteridium ?furcillatum*, suggesting a Visean age.

U.S.S.R.

1. Kuznetzk Basin

Zalessky (1936, 1937) has recorded a few Lower Carboniferous plants from two or three localities (pl. xvii, no. 62). Of these "*Angaropteridium*" *abaeum* might well be a *Cardiopteridium*, while the specimens referred to "*Lophiodendron*", "*Tyrgania*", and "*Demetria*" are merely poorly preserved lepidodendroids. His lists include another *Lepidodendron* and *Asterocalamites scrobiculatus*. Zalessky and Tchirkova (1937, p. 172) remark that the Permian coals in this basin rest on sediments of the marine coastal zone of the Lower Carboniferous, which are partly of Tournaisian and partly of Visean age.

2. Krasnoyarsk Basin

Bazhenov (1938) records Lower Carboniferous sandstones with *Lepidodendron* (pl. xvii, no. 63)

3. Minussinsk Basin

Zalessky and Tchirkova (1937, p. 191) suggest that the lowest beds of the Minussinsk Series (below the Permian coals) may be Lower Carboniferous, and they record the occurrence of *Lepidodendron*, usually in a decorticated condition. Batow (1931, p. 54) had previously listed a few plants identified by Chachlov, which from their names might be Lower Carboniferous or Upper Devonian, but I have seen no figures (pl. xvii, no. 68).

4. Kazakhstan

In north-east Kazakhstan there are extensive deposits of Lower Carboniferous coal (Prigorovskiy, 1937, p. 78), indicating non-marine conditions. The most important of these is the Karaganda basin (pl. xvii, no. 64); some 300 km. to the north-east is the Ekibastuz basin (pl. xvii, no. 69), and between this and Akmolinsk is the Teniz-Korzhanikul basin (pl. xvii, no. 70); there are also other coal deposits of lesser importance. Probably the whole region in Visean times was one of coastal swamps and lagoons, perhaps coincident with the drying up of an arm of the sea. So far not many fossil plants have been described, but there are records of characteristic Lower Carboniferous lepidodendroids and of rare fragmentary frond impressions from Karaganda, Ekibastuz and Kuu-Cheku. (Zalessky, 1918, pls. xii, xiii, lx, lxi; 1932, pp. 130-4; 1933).

Zalessky (1909) also figured a few Lower Carboniferous plants, mainly lepidodendroids with a few fragmentary fronds, from the Mugodzhary Hills (pl. xvii, no. 65); some of the specimens were said to be from the basin of the Alabas, and some from the basin of the Karaganda, but presumably the latter is not the Karaganda of north-east Kazakhstan. Zalessky's localities are more probably in or near what is now known as the Berchogur coal-field, of Lower Carboniferous age, in western Kazakhstan.

5. East of the Urals

In the Bredy district (pl. xvii, no. 66) a Lower Carboniferous flora of possibly Visean age indicates land conditions. Tchirkova (1933, 1937) records a dozen species, mainly of frond genera. Zalessky (1930) described some Lower Carboniferous plants from Podossinino in the Egorshino region, north of Bredy; these are further discussed by Jongmans (1939, p. 103).

6. European U.S.S.R.

The coals of the Kizel Basin, on the western slopes of the Urals (pl. xvii, no. 67) are Lower Carboniferous, and again land must be postulated in this region. I have seen no description of the flora. In the Moscow Basin (pl. xvii, no. 55) the well-known Lower Carboniferous paper-coal is largely composed of compressed lepidodendroid stem cuticles, possibly drifted, but not very far; and the few species so far recorded are listed by Jongmans (1939, p. 15), who also summarizes (pp. 17-37) the "Lower Carboniferous" flora of the Donetsk Basin (pl. xvii, no. 54). Here most of the plants were originally considered to be Visean, but Jongmans has shown them to be Namurian. A possible corollary of this rectification is that Zalessky's "Upper Devonian" beds with a *Lepidodendropsis*-flora may belong to the Lower Carboniferous.

It will be seen that in most regions of Asia the plant-bearing beds of the Lower Carboniferous are less extensively developed, and also perhaps have been less studied than the marine Visean. In attempting to reconstruct the former distribution of land and sea and the main course of the coastlines, however, every record of plant remains is of value, even when the individual specimens are not botanically identifiable.

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X. APPENDIX

LOWER CARBONIFEROUS FOSSILS FROM MALAYA: BRYOZOA, MOLLUSCA AND CRINOIDEA

By KENNETH P. OAKLEY

(Pls. XI and XII)

The present contribution includes a description of the mollusca and crinoid stem-ossicles accompanying the brachiopods and corals from the limestones of the Kuantan district of Pahang, which are described by Dr. Muir-Wood and Dr. Stanley Smith in parts VII and XI of this work. The investigation of the fauna leaves no doubt as to the Visean age of these limestones.

In addition, bryozoa, crinoid stem-ossicles, and a pelecypod are described from shales of the Sungei Terapai stream section, which also yielded plants, brachiopods, and trilobites. A full discussion of these beds by Dr. Muir-Wood will be found in parts III and V; previously mapped as Triassic, they are now shown to be of Visean age.

The limestone localities lie along a north-south line some six or seven miles east of the Sungei Terapai (see sketch-map, fig. 1). The regional dip is believed to be easterly.

1. Limestone Fossils from Kuantan District, Pahang.

The limestones are grey, mainly saccharoidal or more coarsely crystalline; in fact very similar in appearance to much of the Carboniferous Limestone of Britain. They are riddled with calcite veins, and most of the shelly fossils are extensively recrystallized. The limestones appear to be of the normal bedded, shallow-water type. However, small patches of travertine were noted in the matrix of some of the specimens from Bukit Sagu, and this occurrence suggests that reef conditions may have existed locally.

On the evidence of the material collected, particularly the brachiopods, it is concluded that the limestones at Bukit Sagu and Bukit Tinggik, and probably also at Bukit Charas, are of Upper Visean age.

PELECYPODA

Family GRAMMYSIIDAE

GENUS EDMONDIA de Koninck, 1841

Edmondia sp.

MATERIAL.—One poorly preserved left valve in grey saccharoidal limestone [PL. 421].

HORIZON.—Lower Carboniferous, Upper Visean.

LOCALITY.—F.M.S. Geol. Survey No. 14896: east side of Bukit Tinggik, Kuantan, north-east Pahang.

DESCRIPTION.—Shell subquadrate, transversely elongated, gibbous and very inequilateral; dorsal margin nearly straight posteriorly, and sloping downwards; anterior end of valve short, sharply compressed in front of the umbo. The umbo is small, curving inwards and forwards; posteriorly it is continuous with the general convexity of the valve. Greatest convexity about the median transverse diameter. Shell ornamented by broad, flat, imbricate growth-folds, with fine transverse grooves.

MEASUREMENTS.—Length, *circa* 40 mm.; height, *circa* 25 mm.; convexity, *circa* 14 mm.; pre-umbonal length, *circa* 9 mm.

REMARKS.—Owing to the variable characters of many species of *Edmondia*, a single, imperfect specimen is insufficient basis for comparison with described forms.

Family SOLEMYACIDAE

GENUS SOLEMYA Lamarck, 1818

[= *Solenomya* Children, 1823]

? *Solemya* sp.

(Pl. xii, fig. 3)

MATERIAL.—One very imperfect and corroded left valve in grey crystalline limestone full of calcite veins [PL. 419].

HORIZON.—Lower Carboniferous, Upper Viséan.

LOCALITY.—F.M.S. Geol. Survey No. 14895: exposure at foot of Bukit Sagu (south-west side), Kuantan, north-east Pahang.

DESCRIPTION.—Large, transversely elongate, inequilateral shell with strong, radiating, flattened ribs. Only the ventro-lateral part of the valve has been preserved. The ventral margin is transverse and nearly straight, but becoming more convex towards the posterior end. In the region of the valve preserved the ribs are nearly parallel and directed downwards and backwards; there are about three in 10 mm.

MEASUREMENTS.—Estimated length, *circa* 100 mm.; estimated height, *circa* 45 mm.; convexity, *circa* 7.5 mm.

REMARKS.—This specimen is too incompletely preserved for reliable determination. Nevertheless its large size and the rather distinctive ribbing should make it identifiable with any better preserved specimens of the species which may be found at some future date, either in the Malayan Carboniferous or elsewhere.

The tentative reference of this shell to *Solemya* is based on the rather flimsy evidence of the flattened ribs. The shell is reminiscent of some large *Parallelodons*, but it differs from these in the absence of transverse striae or regular growth-folds; nor is there any sign of the median flattening or depression, causing slight insinuation of the ventral margin, common in Palaeozoic *Parallelodons*.

Family PTERINOPECTINIDAE

GENUS PTERINOPECTINELLA Newell, 1938

Pterinopectinella cf. *granosa* (J. de C. Sowerby)

(Pl. xii, fig. 5)

[Cf. *Pecten granosus* J. de C. Sowerby, 1829, p. 144, pl. dlxxiv, fig. 2.

Aviculopecten granosus (Sowerby) Morris, 1854, p. 164.

Pterinopecten granosus (Sowerby) Hind, 1903, pp. 57–8, pl. x, figs. 1–3, 6.

Pterinopectinella granosa (Sowerby) Newell, 1938, pp. 41, 113.]

MATERIAL.—One imperfect left valve in grey crystalline limestone [PL. 418].

HORIZON.—Lower Carboniferous, Upper (?) Viséan.

LOCALITY.—F.M.S. Geol. Survey No. 5048: north side of Bukit Charas, Kuantan, north-east Pahang.

DESCRIPTION.—Shell suborbicular with straight hinge-line; slightly prosocline; moderately inflated apart from compression in the auricular regions and along the dorsal margin. Surface ornamented with radiating, tuberculate, moniliform ribs; secondary ribs (one or two) developed in the folds between the main ones. The ribs are crossed by fine concentric lines of growth.

MEASUREMENTS.—Length, *circa* 40 mm. (estimated); height, *circa* 42 mm.; convexity, *circa* 6.5 mm.; umbonal angle, *circa* 120°; number of main ribs, *circa* thirty.

REMARKS.—As far as it is preserved, this shell agrees with the type of *P. granosa* (Sow.), but complete identification is scarcely warranted by the imperfect preservation of the auricles.

P. granosa occurs widely in the Carboniferous Limestone of Great Britain. It appears to be mainly a Visean species. To mention a few dated occurrences, it is recorded in the Coplow reef-knolls (C₂ subzone) near Clitheroe, Lancashire (Parkinson, 1926, p. 203), in the Cracoe reef-knolls (S₂-D₁ subzones) in West Yorkshire (Garwood and Goodyear, 1924, p. 241), and in the Redesdale Ironstone (D₁ subzone) of Northumberland (Hind, 1903, p. 58).

Family AVICULOPECTINIDAE

GENUS STREBLOCHONDRIA Newell, 1938

? *Streblochondria* sp.

MATERIAL.—Imperfect right (?) valve in grey, finely saccharoidal limestone [PL. 417].

HORIZON.—Lower Carboniferous, Upper Visean.

LOCALITY.—F.M.S. Geol. Survey No. 14896: east side of Bukit Tinggik, Kuantan, north-east Pahang.

DESCRIPTION.—Small orbicular pectinoid, probably opisthocline. The preserved valve moderately flat; smooth except for fine regular fila crossed by faint, broad, radiating costellae, scarcely visible except in the posterior quarter.

MEASUREMENTS.—Length, *circa* 19 mm.; height, *circa* 20 mm.; convexity, *circa* 2.5 mm.; number of costae, thirty? (seven or eight visible in anterior quarter); maximum umbonal angle, *circa* 85°.

REMARKS.—Precise determination is impossible owing to the worn and imperfect condition of the shell. Superficially the specimen resembles various species of *Streblochondria*.

GENUS STREBLOPTERIA M'Coy, 1851

Streblopteria sp.

(Pl. xii, fig. 4)

MATERIAL.—Seven imperfect specimens in grey saccharoidal limestone. Five of the specimens are in the British Museum [PL. 412-6], and two in F.M.S. Geological Survey Department.

HORIZON.—Lower Carboniferous, Upper Visean.

LOCALITIES.—(1) F.M.S. Geol. Survey No. 14896: east side of Bukit Tinggik, Kuantan, north-east Pahang (PL. 412-4; and one in F.M.S. Geol. Survey Dept.); (2) F.M.S. Geol. Survey No. 14895: exposure at foot of Bukit Sagu (south-west corner), Kuantan, north-east Pahang (PL. 415-6; and one in F.M.S. Geol. Survey Dept.).

DESCRIPTION.—Shell orbicular to broadly oval, distinctly opisthocline; somewhat inequivalve, umbones pointed and subcentral; biconvex, left valve more gibbous than right. Hinge margin about half the width of the shell. Posterior umbonal fold ill-defined; anterior umbonal fold distinct, curving outwards. Posterior auricle smooth, poorly defined, with subquadrate margin; anterior auricle well defined, triangular, separated from shell body by deep byssal sulcus. Surface of anterior auricle crossed by four obscure radial costae. Surface of shell body smooth, with faint concentric lines of growth. Where the surface is worn there are traces of fine, slightly wavy, radial costellae.

MEASUREMENTS.—

	Right Valves		Left Valves	
	[PL. 412]	[PL. 414]	[PL. 413]	[PL. 415]
Length . . .	<i>c.</i> 30 mm.	<i>c.</i> 27 mm.	<i>c.</i> 33 mm.	<i>c.</i> 24 mm. (estimate)
Height . . .	<i>c.</i> 30 mm.	<i>c.</i> 26 mm.	<i>c.</i> 35 mm.	<i>c.</i> 25 mm.
Convexity . . .	<i>c.</i> 5 mm.	<i>c.</i> 6 mm.	<i>c.</i> 11 mm.	<i>c.</i> 6 mm.
Hinge length . . .	<i>c.</i> 15 mm.	?	?	<i>c.</i> 13 mm. (estimate)

REMARKS.—The material described above probably represents a new species, but it is not sufficiently complete for specific diagnosis. It is tentatively referred to *Streblopteria* although the radial costae on the anterior auricle are not a typical feature of this genus. Hind, however, included within the type-species, *S. laevigata* (M'Coy), specimens apparently showing such costae (1903, pl. xi, fig. 7).

In the general form of the shell body the Malayan specimens recall *Streblopteria hemispherica* (Phill.). In the character of the anterior auricle they closely resemble "*Pseudomonotis*" *kumpani* Fedetov, a species ranging through the Middle and Upper Carboniferous in the Donetz Basin (cf. Fedetov, 1932, pp. 189–91, pl. xii, fig. 15). In this Russian form, the generic status of which is still uncertain, the right valve is nearly flat. Nevertheless it is quite likely to be a derivative of the stock represented by the Viséan form here described.

GASTROPODA

Family PLATYCERATIDAE

GENUS ORTHONYCHIA Hall, 1843

Orthonychia sp.

(Pl. xii, fig. 6)

MATERIAL.—One specimen in grey saccharoidal limestone [PG. 875].

HORIZON.—Lower Carboniferous, Upper Viséan.

LOCALITY.—F.M.S. Geol. Survey No. 14895: exposure at foot of Bukit Sagu (south-west corner), Kuantan, north-east Pahang.

DESCRIPTION.—Nearly symmetrical horn-shaped shell; apex closely incurved, but not enrolled; rapidly expanding; posteriorly the dorsum has shallow median sulcus. Apex subcentral and immediately over anterior margin of aperture. Aperture nearly circular. Surface of shell smooth; conspicuous growth-line 1.5–2.0 mm. above apertural margin.

MEASUREMENTS.—Length (anterior-posterior diameter of aperture), 12 mm.; width (transverse diameter of aperture), 12 mm.; height, 6.5 mm.; height of apex above apertural margin, 3 mm.

REMARKS.—Capuliform platyceratids such as this are commonly found attached to other organisms, particularly to crinoids. Comparison might be made with the larger *Orthonychia equilatera* (Hall) occurring in the Keokuk group (Mississippian) of Illinois (Meek and Worthen, 1873, p. 518, pl. xvii, fig. 2) and with *O. parasitica* (Trautschold), found in the Middle Carboniferous (Myatschkovian) of the Moscow Basin (Trautschold, 1867, p. 41, pl. v, fig. 5).

Platyceratids which are nearly symmetrical about the median plane, and have incurved, but not enrolled, beaks are sometimes grouped under the name *Palaeocapulus* Grabau and Shimer. They constitute, however, no more than a form-genus. *Palaeocapulus* is now recognized to be a subjective synonym of *Orthonychia* Hall (see Knight, 1941, p. 228).

SCAPHOPODA

Family DENTALIIDAE

GENUS DENTALIUM Linnaeus, 1758 (sens. lat.)

? "*Dentalium*" sp.

MATERIAL.—One imperfect specimen in light-grey saccharoidal limestone [PG. 874.]

HORIZON.—Lower Carboniferous, Upper Viséan.

LOCALITY.—F.M.S. Geol. Survey No. 14895: exposure at foot of Bukit Sagu (south-west corner), Kuantan, north-east Pahang.

DESCRIPTION.—Cylindrical portion of a straight or imperceptibly curved, slowly enlarging shell with elliptical cross-section. The outer surface shows unevenly developed annular growth-rugae, obscuring the fine longitudinal costae which formed the original ornament of the test. Traces of the longitudinal costae can be seen on the internal cast of the shell where the test has broken away. There are about ten costae in a quarter of the circumference.

MEASUREMENTS.—Length preserved, 31 mm.; original length (estimated), ? *circa* 100 mm.; longer diameter, 5 mm.; shorter diameter, 4 mm.; thickness of test, 0.3 mm.

REMARKS.—There can be little doubt that this is one of the scaphopoda; probably "*Dentalium*", although the obscuring of the longitudinal costation by a layer showing annular growth-lines is an unusual feature in the genus. This thickening may be a senile condition.

CRINOIDEA

Family POTERIOCRINIDAE

Gen. et Sp. indet.

"*Poteriocrinus*" sp.

MATERIAL AND LOCALITIES.—Several stem-ossicles (columnals) belonging to a generalized type common in Upper Palaeozoic rocks, generally recorded as *Poteriocrinus*, occur in the collections from (1) F.M.S. Geol. Surv. Loc. No. 14895: exposure at foot of Bukit Sagu (south-west corner), Kuantan, north-east Pahang; and (2) F.M.S. Geol. Survey Loc. No. 14896: east side of Bukit Tinggik, Kuantan, north-east Pahang [E. 26406].

HORIZON.—Lower Carboniferous, Upper Viséan.

DESCRIPTION.—A typical specimen [E. 26406] has a diameter of 17 mm.; the segments are thin, about ten occurring in a length equal to the diameter. The central canal has a diameter of about 8.5 mm.

REMARKS.—Reliable generic determination is not possible in the case of such crinoid stems on account of homoeomorphy in the group.

2. Fossils from the Sungei Terapai Shale.

The so-called shale is actually a soft argillaceous siltstone, probably black and carbonaceous in depth, but weathered at the surface to a mottled bluish-grey and whitish colour, with tinges of rust. It is interbedded with quartzitic sandstones. The fossils are preserved as moulds or as argillaceous casts, the rock being completely decalcified.

The restricted character of the fauna in the Sungei Terapai shale suggests that it was laid down under lagoonal conditions, similar to those responsible for the *alpha*-limestones (bryozoan) of the British Lower Carboniferous. The lithology of the bed and the conditions of deposition have already been commented on by Dr. Muir-Wood (parts III and V).

No reliable conclusion can yet be reached on the relationship between this shaly-arenaceous series and the neighbouring Kuantan limestones. Both are of Lower Carboniferous age, both apparently Viséan. On the evidence of the brachiopod fauna Dr. Muir-Wood is inclined to refer the shale fauna to an earlier stage of the Viséan than the limestones. The bryozoa in this deposit are too poorly preserved for close determination, and in any case they belong to species-groups with fairly long ranges, so that their dating value is small. However, they appear to indicate a post-Tournaisian age. The assemblage of Fenestellids is perhaps most closely comparable with that in the *Kulmgrauwacke* of the Harz Mountains, which is of Upper Viséan-Namurian age (see Nekhoroshev, 1932, p. 70).

BRYOZOA

Order CYCLOSTOMATA

Family FISTULIPORIDAE

GENUS FISTULIPORA M'Coy, 1850

Fistulipora sp.

MATERIAL.—Four poorly preserved casts. Two are in the British Museum [D. 36443-4], and two in F.M.S. Geological Survey Department.

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Laminar zoarium, oval or elongate; external surface with moderately conspicuous maculae; zooecial apertures pyriform and distinctly oriented, narrow ends proximal to the maculae.

MEASUREMENTS.—Largest zoarium, 20 mm. $\times$ 8 mm.; distance between maculae, ? 6.5 mm.; number of zooecia in 2 mm., four to five.

REMARKS.—The material is too poorly preserved to warrant specific comparisons. Lower Carboniferous bryozoan assemblages commonly include at least one laminar or massive species of *Fistulipora*.

Order CRYPTOSTOMATA

Family FENESTELLIDAE

GENUS FENESTELLA Lonsdale, 1839¹*Fenestella* cf. *angustata* (Fischer v. Waldheim)

(Pl. xi, fig. 2)

[Cf. *Retepora angustata* Fischer v. Waldheim, 1837, p. 165, pl. xxxix, fig. 3;

Fenestella angustata (Fischer) Nikiforova, 1938, pp. 81-2.

Cf. *Fenestella angustata* (Fischer): Nekhoroshev, 1932, pp. 51-2, pl. i, figs. 6, 6 a-c.

Cf. *Fenestella angustata* (Fischer): Prantl, 1934, p. 227, pl. i, fig. 1.]

MATERIAL.—Two specimens, one a mould of a zoarium in reverse aspect, the other a mould of a zoarium in obverse aspect with counterpart (internal cast) [D. 36442, D. 36446].

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Zoarium flabelliform; structure regular; branches straight, undergoing moderately frequent dichotomy, longitudinally striated on reverse side; dissepiments thinner than the branches, very slightly expanded at junctions; fenestrules subrectangular. All other details obscured.

MICROMETRIC FORMULA.²—18-20/12-14/circa 20.

MEASUREMENTS.—Larger specimen preserved to height of 22 mm., and to width of 15 mm.

Branches: number in 10 mm., 18-20; width, 0.22-0.28 mm.

Dissepiments: number in 10 mm., 12-14; width, circa 0.17 mm.

Fenestrules: width, 0.28-0.33 mm.; length, 0.5-0.6 mm.

Zooecia: number in 5 mm., circa 20.

¹ In accordance with the recommendations of Condra and Elias (1941), it is proposed to use *Fenestella* Lonsdale (preoccupied by *Fenestella* Bolten, 1798 = *Anomia* Linn., 1758) until the question of its conservation has been considered by the International Commission on Zoological Nomenclature.

² Branches in 10 mm. across/fenestrules in 10 mm. longitudinally/zooecia in 5 mm. in vertical series.

REMARKS.—Fenestellids comparable with *Fenestella angustata* (Fischer) have a long range. In Russia this species has been recorded from Visean, Moscovian, and Uralian beds (Nikiforova, 1933b, pp. 10–11). The type of *F. angustata* came from Moscovian beds in the Moscow Coal Basin and has the micrometric formula $18-19/10-10\frac{1}{2}/20$. When some of the specimens from other horizons which have been recorded as *F. angustata* are compared with the detailed description of the holotype (Nikiforova, 1938, pp. 81–2) it becomes evident that the name has been applied too widely (cf. *ibid.*, pp. 98–9). The present specimens agree closely in observable features with some, hitherto referred to *Fenestella angustata*, from the Visean of Germany having the formula $18-20/12/20$, branches 0.23–0.25 mm. in width, dissepiments 0.05 mm. in width, and fenestrules 0.3–0.35 mm. wide, 0.75–0.85 mm. long (Nekhoroshev, 1932, pp. 51–2); and with specimens similarly identified from the Dobšina shales (*zeta*-horizon) in Slovakia, also of Visean age: $19-20/12-13/21-22$, branches 0.19–0.23 mm. wide, dissepiments 0.15–0.17 mm. wide (Prantl, 1934, p. 227). All these differ from the typical *F. angustata*, for instance, in having slightly shorter fenestrules, which appear more subrectangular than long-oval.

***Fenestella* cf. *tenax* Ulrich**

(Pl. xi, fig. 1)

[Cf. *Fenestella tenax* Ulrich, 1890, p. 546, pl. li, figs. 2, 2a–e

Fenestella tenax Ulrich; Nekhoroshev, 1926, p. 1248, pls. xix, fig. 12, and pl. xx, fig. 1.]

MATERIAL.—Seven specimens, mainly external moulds. Five are in the British Museum [D. 36433–7]; and two in F.M.S. Geological Survey Department.

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Delicate foliate zoarium; structure very regular and fine; branches straight, dichotomy infrequent; dissepiments thinner than the branches; fenestrules rectangular.

MICROMETRIC FORMULA.— $28-30/22-24/circa\ 26$.

MEASUREMENTS.—Largest fragment preserved: height, 30 mm.; width, 35 mm.

Branches: number in 10 mm., 28–30; width, 0.14–0.16 mm.

Dissepiments: number in 10 mm., 22–24; width, 0.09 mm.

Fenestrules: width, 0.2 mm.; length, 0.35 mm.

Zooecia: number in 5 mm., *circa* 26.

REMARKS.—*Fenestella tenax* Ulrich was originally described from Upper Mississippian horizons in Illinois (Warsaw beds) and Kentucky (Warsaw beds and Chester group). Nekhoroshev (1926) has since identified it in the Lower Carboniferous (base of Visean) of the Kuznetzk Basin, U.S.S.R. Nikiforova (1933a, p. 15) described a form in the Lower Carboniferous of Turkestan as *Fenestella* cf. *tenax* Ulrich, with the formula $26-30/26-27/>25$. Prantl describes another comparable form in the Dobšina shales (*zeta*-horizon) of Slovakia (Visean) as *Fenestella* aff. *tenax*: $31-32/25-26/26-27$ (Prantl, 1934, p. 231, pl. i, fig. 2).

The formula of the typical form from the Warsaw and Chester groups is $28-30/29-30/27-29$. There is, however, a variety in the Chester group which is more comparable with the Malayan form in its micrometric proportions: $28-29/23/24-25$ (Ulrich, 1890, p. 546). This is closely paralleled by the Kuznetzk form, which has the formula $26-28/22-25/24-26$ (Nekhoroshev, 1926, p. 1248).

***Fenestella* cf. *polyporata* (Phillips)**

(Pl. xii, fig. 1)

[Cf. *Retepora polyporata* Phillips, 1836, pp. 199, 245, pl. i, figs. 19, 20.

Fenestella polyporata (Phillips) Shrubsole, 1881, p. 185.

Fenestella polyporata (Phillips): Nikiforova, 1927a, pp. 176, 179, pl. v, fig. 4.

Fenestella polyporata (Phillips): Nikiforova, 1933a, p. 23, pl. vi, fig. 14.]

MATERIAL.—Five specimens, mainly external moulds, but including one decayed internal

cast. Four are in the British Museum [D. 36438-41]; and one in F.M.S. Geological Survey Department.

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Zoarium flabellate; structure irregular and coarse; dichotomy frequent; fenestrules very elongate, three times as long as wide; dissepiments much thinner than branches, and with scarcely appreciable expansion at junctions. Zooecia apparently large, the peristomes giving rise to protuberances along the margins of the branches.

MICROMETRIC FORMULA.—14/6/18-20.

MEASUREMENTS.—Largest zoarium preserved, height, 17 mm.; width, 20 mm.

Branches: number in 10 mm., 14; width, 0.23-0.25 mm.

Dissepiments: number in 10 mm., 6; width, 0.13-0.17 mm.

Fenestrules: width (average), 0.6 mm.; length (average), 1.9 mm.

Zooecia: number in 5 mm., 18-20.

REMARKS.—*Fenestella polyporata* occurs typically in limestones and shales of Visean age in Britain. The type is not available for comparison, but a specimen from the Black Limestone (Upper Visean) of Halkyn Mountain, Flint, in the British Museum collection [D. 36430], identifiable with the typical form, has been measured and showed the proportions 12-15/6/18.

Fenestella polyporata has been identified by Nikiforova (1927a, p. 179; 1933a, p. 23) in the Lower Carboniferous of Turkestan. The range of variation of the Asiatic specimens is covered by the formula 9-12/4-6/16. Closely related forms occur in the base of the Visean stage in Altai (Nikiforova, 1933b, p. 13) and in the Beschevo zone (=D₃ subzone) of the Donetz Basin (Nikiforova, 1927b, p. 251).

Fenestella aff. *plebeia* M'Coy

(Text-fig. 2)

[Cf. *Fenestella plebeia* M'Coy, 1844, p. 203, pl. xxix, fig. 3.

Fenestella plebeia M'Coy: Shrubsole, 1881, p. 179.]

MATERIAL.—Two specimens, one a decayed internal cast, the other an external mould [D. 36431-2].

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Zoarium flabellate; structure moderately regular, somewhat coarse; branches slightly flexuose and outcurving; dichotomy moderately frequent, particularly in the proximal part; dissepiments finer than branches, and below the level of their upper surface; fenestrules elongate elliptical. Zooecia long-triangular in section, and arranged in close alternation (text-fig. 2).

MICROMETRIC FORMULA.—18/8-9/18-20.

MEASUREMENTS.—Zoarium: maximum height, 30 mm.; maximum width, 25 mm.

Branches: number in 10 mm., 18; width, 0.25-0.4 mm.

Dissepiments: number in 10 mm., 8-9; width, 0.17-0.3 mm.

Fenestrules: width, 0.2-0.3 mm.; length, 0.6-0.85 mm.

Zooecia: number in 5 mm., 18-20; width, 0.18 mm.; length, 0.29 mm.

REMARKS.—*Fenestella plebeia*¹ represents a species-group ranging from the Lower Visean to the Uralian which is practically cosmopolitan, being found in Europe, Asia (see Nikiforova, 1933b, pp. 12-13), Australasia, and North America (where it is represented by *F. rudis* Ulrich, closely related to, if not conspecific with, *F. plebeia* M'Coy).

A specimen of *F. cf. plebeia* from the Black Limestone (Upper Visean) of Halkyn Mountain, Flint, in the British Museum collection [D. 36429] shows the proportions, 19/10/18. The Malayan form has more elongate fenestrules, recalling in this respect *F. plebeia* var. *longifenestra*.

¹ The holotype of *Fenestella plebeia* M'Coy (1844, pl. xxix, fig. 3), preserved in the National Museum of Ireland, Dublin, was not accessible under the wartime conditions existing when this was written. However while the present monograph was going through the press I was able, through the courtesy of Dr. O'Connor, to examine this important type. It is labelled "Carboniferous Slate", but is evidently from basal Lower Limestone (? Lower Visean, according to Mr. J. Selwyn Turner), of Killybrone, N.W. of Killala, Co. Mayo; and it has the micrometric formula 18/8-9/c. 16.

Nikiforova, a variety occurring in the Beschevo zone (=D₃ subzone) of the Donetz Basin and having the formula $16-18/7\frac{1}{2}-8/20$ (Nikiforova, 1927b, pp. 246, 251, pl. xiii, figs. 1-3).



Fig. 2.—*Fenestella* aff. *plebeia* M'Coy. Tangential section (semi-diagrammatic). x 50. Based on internal cast in the Sungei Terapai shale (Visean). [D. 36431].

Family CYSTODICTYONIDAE

GENUS CYSTODICTYA Ulrich, 1822

Cystodictya sp.

MATERIAL.—One incomplete ferruginous cast [D. 36445].

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Narrow, parallel-sided, bifoliate zoarium, branched dichotomously; zooecia oblique; zooecial apertures nearly circular, or slightly long-oval, arranged in longitudinal and diagonal series. No maculae observed.

MEASUREMENTS.—Width of zoarium, *circa* 2 mm.; length of zoarium below bifurcation, 7 mm.; length of zoarial branch, above bifurcation, 7 mm.; angle of bifurcation, *circa* 30°; number of longitudinal rows of zooecial apertures, 9-10; number of zooecial apertures in 2 mm. diagonally, 9½; diameter of zooecial aperture, 0.17-0.2 mm.

REMARKS.—The poor preservation and incompleteness of the specimen precludes specific comparisons. Species of *Cystodictya* similar to this in general character are moderately common in Lower Carboniferous rocks.

PELECYPODA

Family NUCULANIDAE?

GENUS ANTHRAONEILO Girty, 1911

Anthraconeilo aff. *taffiana* Girty

(Pl. xii, fig. 2)

[Cf. *Anthraconeilo taffiana* Girty, 1911, p. 132.

Anthraconeilo taffiana Girty, 1915, pp. 114-15, pl. xv, figs. 9-13.

Anthraconeilo taffiana Girty: Fedetov, 1932, pp. 24-5, pl. i, figs. 17-20.]

MATERIAL.—One right valve in soft siltstone [PL. 420].

HORIZON.—Lower Carboniferous, Visean.

LOCALITY.—Sungei Terapai, north of Sungei Lembing village, Kuantan, north-east Pahang.

DESCRIPTION.—Thin, transverse, sub-elliptical, inequilateral shell; width nearly twice the height. Beak small, pointing to shorter side. Valve acutely rounded anteriorly, tapering to sub-truncate termination posteriorly; greatest height and convexity one-third the shell length from

the anterior end; compressed posteriorly and slightly at anterior margin also; dorsal margin behind the umbo rectilinear, ventral margin arched, becoming subrectilinear posteriorly. Surface of shell smooth, with faint concentric growth striae.

MEASUREMENTS.—Length, 19 mm.; pre-umbonal length, 5 mm.; height, 9 mm.; convexity, *circa* 3 mm.

REMARKS.—Owing to the poor preservation of the actual ostracum, dissection failed to reveal the character of the dentition—apart from faint indications of its being taxodont. Thus the generic identification of this specimen rests essentially on the external form. The slight but distinct turning of the umbonal beak towards the shorter side is the most important character observed. This is the condition of *Nucula*, *Nuculopsis*, *Palaeoneilo*, and *Anthraconeilo*, whereas in *Yoldia* and *Niculana* the beak is inclined towards the longer side. The present form agrees with *Anthraconeilo*, but differs from *Nucula* and *Nuculopsis* in its transverse extension, and from *Palaeoneilo* in the absence of sinuation in the ventral margin.

The longer side is anterior in *Nucula*, but posterior in *Nuculopsis* and *Palaeoneilo* (see Girty, 1915, pp. 107ff.). Girty originally contended that *Anthraconeilo* agreed with *Nucula* in this respect, but later he seems to have had some doubt about this (Girty, 1911, p. 132; 1915, p. 113). To the present author the evidence appears more to favour the reverse interpretation, that the longer side is posterior in *Anthraconeilo* as in *Niculana*, and the description of the specimen is worded accordingly.

The Malayan specimen seems to approach very closely the type-species, *A. taffiana* Girty, originally described from the Wewoka formation (Pennsylvanian) of Oklahoma, and since found in Middle Carboniferous beds (C_2^4) in the Donetz Basin (Fedetov, 1932). Specific identity cannot be proved on this single specimen, and is perhaps rather unlikely in view of the Lower Carboniferous age of the bryozoa-brachiopod fauna associated with the Malayan form.

CRINOIDEA

Family POTERIOCRINIDAE

Gen. et. sp. indet.

“*Poteriocrinus*” sp.

Impressions of numerous small stem-ossicles of the generalized type usually referred to *Poteriocrinus* occur in the Sungei Terapai shale (Visean) in association with bryozoa and brachiopods.

These columnals range in diameter from 2.5 to 5 mm. Their lumen is approximately half the diameter of the stem. The flat peripheral articulating-area bears fine radial ribs and occupies approximately three-eighths of the radius. This area is separated from the central canal by a counter-sunk rim with a width of about one-eighth of the radius. A stem with diameter of 3 mm. has eight segments in the equivalent length. The lateral surfaces of the segments are tuberculate.

Reliable determination of such stem-ossicles is not at present possible. Specimens are preserved in the British Museum [E. 26407-8] and in F.M.S. Geological Survey Department.

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XI. APPENDIX

CARBONIFEROUS CORALS FROM MALAYA

By STANLEY SMITH
(Bristol University)

(Pl. XV)

The collection of fossils recently made in the Kuantan district of Pahang included only one coral, from Bukit Tinggik, described here as *Amygdalophyllum* sp. I have, however, re-examined other material in the British Museum from the same region with the aid of newly-prepared thin-sections, and revised my earlier identifications (Smith, 1920) in the light of our increased knowledge of Palaeozoic corals and of changes in nomenclature. Most of the specimens have been cut into two or more pieces, and each piece has been registered under a separate number. Specific determinations are scarcely possible, and consequently the corals by themselves throw little light on the exact age of the rocks in which they are found; for a full discussion of the age and relationships of the beds reference should be made to Dr. H. M. Muir-Wood's contribution, in which the fauna is shown to be Lower Carboniferous (Visean).

Indeterminable Rugose Corals

Two specimens of rugose corals (**R. 18690-1**) from Gua Sah, north-west of Kuala Lipis, Ula district, Pahang, recorded by Scrivenor (1911, p. 34) as "coral remains", cannot be determined since their structure has been destroyed through recrystallization.

CANINIA Michelin in Gervais, 1840, p. 485

Caninia near **C. gigantea** Michelin

See *Caninia gigantea* Michelin, 1843, p. 81, pl. xvi, figs. 1 a-e.

Siphonophyllia cylindrica Scouler MS. in M'Coy, 1844, p. 187, pl. xxvii, fig. 5 (by which name the species is very generally but incorrectly known).

Caninia cylindrica (Scouler) Salée, 1910, p. 27, pls. ii-v (for good description and figures of the species).

British Museum specimen **R. 19096-8** from Bukit Charas, Kuantan, is a species of *Caninia* near *C. gigantea* Michelin as previously recorded (Smith, 1920, p. 4), and there is little to add to what has been stated already. It is part of a cylindrical individual about 35 mm. in diameter, and its dissepimentarium, which is between 2 mm. and 3 mm. wide, is not traversed by the septa. The major septa only are developed. They are short, thin, and somewhat twisted, and leave a great part of the tabularium free. The tabulae, which as in typical forms of *C. gigantea* are to a great extent complete and only slightly vaulted, are crumpled. The dissepiments are large but compressed. The form is smaller than the typical members of Michelin's species, has a narrower dissepimentarium, and no minor septa, which, although feebly developed, are present in the latter. *Caninia gigantea* attains a diameter of 50 mm. or more, and has often a very wide dissepimentarium. It reaches its highest development in mid-Avonian time—in the *Syringothyris* and lower *Seminula* zones. In size, and in its transverse section, the Malayan coral recalls the Upper Visean *Caninia* from the *Dibunophyllum* zone in the Bristol district, which was figured by Vaughan (1903, pl. i, fig. 5) as "*Campophyllum* aff. *murchisoni* E. & H."

R. 19108, also from Bukit Charas, is a small *Caninia* only 10 mm. in diameter running obliquely through a thin piece of crystalline limestone, and most probably represents an early stage in the ontogeny of **R. 19096-8**. All that the section in the limestone shows is a few very thick, short, wedge-shaped septa attached to an equally stout epitheca.

LITHOSTROTION {DIPHYPHYLLUM}

Diphyphyllum Lonsdale, 1845, p. 622

Diphyphyllum Lonsdale—genoholotype (by monotypy) *D. concinnum* Lonsdale, 1845, p. 624, pl. A, figs. 4, 4 a-c, Lower Carboniferous, Ural Mountains, Russia—is considered by Smith and Lang, 1930, p. 179, to be a genomorph of *Lithostrotion* Fleming, 1828, p. 508, and not a genus.

Lithostrotion {Diphyphyllum} sp.

(Pl. xv, fig. 1)

Diphyphyllum sp., Smith, 1920, p. 4.

British Museum specimen **R. 19105-6** (Bukit Charas) includes a few small fragments of a slender, cylindrical coral about 10 mm. in diameter embedded in limestone. There can be little doubt that these fragments, the largest of which is only 20 mm. long, represent the broken corallites of a phaceloid non-columellate *Lithostrotion*. The tabularium is about 6 mm. in diameter and the dissepimentarium is approximately 2 mm. wide. The septa, of which there are about sixty, are both strongly dilated and strongly carinate. The major septa extend only a short distance into the tabularium, while the minor terminate at the inner border of the dissepimentarium. The tabularium is occupied by a column of superposed, gently domed, axial tabulae, which are mostly complete and approximately 3 mm. in diameter, and by a periaxial development of small, in most cases strongly arched tabellae, of which the inner members are convex towards the periphery of the corallite and the outer members are convex towards its axis. The dissepiments are small and globose.

The outstanding characters of this species are the highly carinate septa and the periaxial tabellae. In the former character, as well as in size, the corallites resemble a non-columellate lithostrotionid (not yet named)¹ which occurs in the *Syringothyris* zone in various parts of Britain, but in the British form the axial ends of the septa are deflected and unite, and thus give rise to an inner annular wall or aulos. In some cases, however, in which the aulos is less perfectly formed, the axial tabulae approach more closely in character those of the Malayan corallites here described.

AMYGDALOPHYLLUM Dun and Benson

(See Dun and Benson, 1920, p. 339; Benson and Smith, 1923, p. 161; and Hill, 1934, p. 69)

The genoholotype (by monotypy) of *Amygdalophyllum*—*A. etheridgei* Dun and Benson, 1920, p. 339, pl. xvii, figs. 2-6 (non fig. 1); Benson and Smith, 1923, p. 161, pl. viii, figs. 1-3, pl. ix, fig. 2, Lower Carboniferous, Viséan, Babbinsboon, New South Wales, Australia—is a simple Rugose coral, trochoid to cylindrical in shape, which attains a length of at least 80 to 100 mm. and a diameter of 40 mm. It has a large fibrous columella, elliptical and cuspidate in transverse section, dilated major septa which reach this columella, minor septa which are nearly as long as, but are appreciably thinner than, the major, small arched tabellae, and fine dissepiments which form a wide dissepimentarium. The fossula is inconspicuous.

Amygdalophyllum sp.

(Pl. xv, figs. 2, 3, 4)

Cyathaxonia sp., Smith, 1920, p. 4.

A tall cylindrical *Amygdalophyllum* from Bukit Charas and Bukit Tinggik differs from the genotype in being much less robust, in having septa which do not all reach the columella, and in displaying a greater disparity in length between the major and minor septa. In other characters

¹ Since named *Aulina horsfieldi* Smith and Yü (1943, p. 49).

the Malayan species agrees very closely with *A. etheridgei*. The enlarged columella, or as it may perhaps be more appropriately termed, "solid axial column", encloses a median plate and the axial ends of the major septa which may remain continuous with or may be dissociated from the septa. In the early growth stages of the coral, the peripheral parts of the septa are so dilated that they are laterally contiguous and form a peripheral stereozone, and all the major septa reach the columella (pl. xv, fig. 2); but in the mature stage the septa attenuate peripherally and cease to be in lateral contact. Moreover, many of the major septa become separated from the columella (pl. xv, fig. 3). The minor septa, which, as in *A. etheridgei*, are appreciably thinner than the major, are at this stage about half as long as the latter. The tabellae are small, strongly arched, convex, and incline towards the periphery. The dissepiments are very small and globose.

In its diameter and also possibly in details of internal structure, *Amygdalophyllum* sp. approaches more closely to some of the Australian Lower Carboniferous species of *Amygdalophyllum* described by Hill (1934, pp. 68-72) than to the genotype. The most striking feature of the coral is the length that the comparatively slender corallum attains. I abstain from attaching a name to this Kuantan species since none of the present specimens is perfect enough to provide an adequate type.

DESCRIPTIONS OF SPECIMENS:

Specimen **R. 19099-102** (pl. xv, fig. 3), Bukit Charas. The cylindrical corallum, although imperfect—both the proximal and distal parts are missing—is 110 mm. long and only 15 mm. in diameter. It is remarkably straight and is ephebic in character throughout. There are nearly forty septa in each cycle. The major septa are moderately dilated, but attenuate peripherally as well as axially. Only a few of them reach the columella. The minor septa are appreciably thinner than the major.

Specimen **R. 19103-4**, Bukit Charas. The specimen, 45 mm. in length, includes the calice, but not the proximal end. The distal diameter is 19 mm., and the proximal one (near to where the coral passes obliquely out of the limestone) is 10 mm. Like most of the other specimens in the collection, only one side of the coral is present in the matrix. The calice is about 10 mm. deep, and has steep, almost vertical sides. A section cut 10 mm. or so below the calice coincides with the stage at which the neanic characters are giving place to the ephebic. Some of the septa are still very strongly dilated peripherally and are in lateral contact, but most of them have become attenuated at the periphery and are well separated. Several of the major septa reach the columella. The columella, of which only part is present in the section, is smaller and less compact than in other specimens.

The importance of specimen **R. 19103-4** lies in the fact that it forms a valuable link between **R. 19099-102**, which only exhibits ephebic characters, and **R. 34005**, which is entirely neanic. Thus it supplies conclusive proof that the two forms are conspecific, a matter which would otherwise have remained in doubt.

In the matrix of **R. 19104** there is also present a small conical coral, 7 mm. tall and 7 mm. wide, which may well be a very young individual of the same species.

Specimen **R. 34005** (pl. xv, fig. 2), Bukit Tinggik, Kuantan. This piece of coral, now entirely represented by sections, was only 10 mm. long. Its distal diameter was 10 mm. and proximal one 6 mm. There are thirty-five major septa, most, if not all, of which reach the columella. These are peripherally expanded to form, with the short, wedge-shaped minor septa, a stereozone 1 to 1.5 mm. wide. The fragment clearly represents the neanic stage of the species.

Specimen **R. 19107**, Bukit Charas, is merely a flake oblique but nearly parallel to the axis of a coral at least 22 mm. in diameter. It exemplifies a corallum of larger size than the other specimens.

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XII. APPENDIX

CARBONIFEROUS TRILOBITES FROM MALAYA

By C. J. STUBBLEFIELD

(Geological Survey and Museum)

(Pls. XIII, XIV)

The trilobites forming the basis of this account were among marine fossils from an exposure discovered by a rock collector attached to the Malayan Geological Survey, at a locality in north-east Pahang on the Sungei Terapai, about $2\frac{1}{2}$ miles upstream from its confluence with the Sungei Kuantan, a river of which it forms a tributary and which drains the Pahang Consolidated Company's Tin Mining Concession in east Pahang (see Locality Map in Muir-Wood, part III). Mr. F. H. Fitch made further collections from this exposure. The trilobites, which seem to be the first to be found in Malaya, occur in a powdery argillaceous siltstone which is white in colour, but blotched with grey; associated are brachiopods such as *Chonetes*, *Leptaena*, *Hustedia*, and *Punctospirifer*, which are described by Dr. Helen M. Muir-Wood (part VII); bryozoa and mollusca described by Dr. K. P. Oakley (part X); and crinoid stem-columns.

From an outcrop on the Sungei Terapai, about half a mile nearer the Sungei Kuantan confluence, Mr. Fitch discovered fossil plants that he considers occur at approximately the same geological horizon in a series of shales and quartzites in which shales predominate. Those plants are described by Mr. W. N. Edwards in part IX of this publication. Until the discovery of these fossils the sediments were thought to be of Triassic age, although Mr. J. B. Scrivenor has stated that "some of the quartzite of Malaya mapped as Triassic may be late Palaeozoic" (Scrivenor, 1931, pp. 52-3). According to the evidence of the brachiopods and bryozoa (*op. cit. supra*) the strata are thought to be Visean in age, but for further discussion see Muir-Wood, parts III and V.

The trilobites comprise seven specimens which have been presented to the British Museum (Natural History) by Mr. E. S. Willbourn, former Director of the Malayan Geological Survey, and registered as **In.38824-30**. They are not closely related to the species figured by Reed (1920, pl. ii, figs. 17, 18) from the *Posidonia* siltstones of southern Siam, but, of other described trilobites, as far as the cephalic characters can be judged from the published illustrations, they appear to include relatives of Russian species, such as "*Phillipsia* sp. No. 3" Weber and *Phillipsia tulensis* Ivanow in Weber; moreover, the pygidia attributed to the latter species resemble some of the pygidia found associated with the Malayan cephalae. With the restriction by Weller (1936) of the generic concept of *Phillipsia* Portlock to the species closest to the genolectotype, *P. kellii* Portlock, the Malayan form and its relatives must be referred to a new genus.

Family PROETIDAE

Linguaphillipsia gen. nov.

DIAGNOSIS.—Phillipsiid Proetid with cephalon having flat or gently convex marginal border in front of glabella, short pre-glabellar field which is usually but a marginal furrow, wider marginal border on free cheek. Glabella longer than wide, not expanded anteriorly; sides subparallel as far as furrows lying third from occipital furrow; thence forming a crescentic curve towards the occipital furrow; widest at the basal lobes; basal furrows strongly curved towards but not necessarily reaching occipital furrow. Palpebral lobes relatively small. Thorax and pygidium imperfectly known.

GENOTYPE.—*Linguaphillipsia terapaiensis* sp. nov. Lower Carboniferous, Sungei Terapai, north of Sungei Lembing village, north-east Pahang, Malaya.

SOME FORMS ASSIGNED TO THIS GENUS.—"*Phillipsia laticaudata* var. *kuzneciana*? Weber

(*amarginata*? Weber)" Weber, 1937, p. 127, pl. v, figs. 24, 25. Tournaisian, Kuznetzk Basin, U.S.S.R. (cranidia only).

Phillipsia tulensis Ivanow in Weber, 1937, p. 147, pl. xi, figs. 20-24. C₂² Viséan, Moscow Basin.

"*Phillipsia* sp. No. 3 (*P. kasakensis* var. *aryssica*? Weber)" Weber, 1937, p. 37 (pl. iv, fig. 24?), pl. x, fig. 36. Tournaisian, Turkestan, U.S.S.R.

"*Phillipsia* sp. No. 9 (cf. *Phill. collinsi* Mitch.)" Weber, 1937, p. 59, pl. vi, fig. 43. Tournaisian, Turkestan, U.S.S.R. (cranidium only).

?*Phillipsia collinsi* Mitchell, 1918, p. 444, pl. xlvi, figs. 1, 2 (?3-5); pl. xlvi, fig. 8 (pl. lii, fig. 4?); possibly pl. xlvi, fig. 9. Lower? Carboniferous, Glen William Road, one mile from Clarencetown, Parish Parr, Co. Durham, New South Wales. The cranidium figured as pl. xlvi, fig. 1, is presumably the same as that shown as pl. xlvi, fig. 8.

Other forms which show affinities with the genus, but probably not congeneric, are:

Phillipsia colei M'Coy, 1844, p. 161, pl. iv, fig. 6; Griffiths in M'Coy, 1862, pp. 224, 256, possibly H. Woodward, 1883, p. 16, pl. ii, figs. 1-6. Lower Carboniferous, Co. Donegal, Eire.

Phillipsia bitumulata Weber, 1932, p. 125, pl. iv, figs. 1-15, text-fig. 12, p. 46; Weber, 1937, p. 58, pl. vi, figs. 33-5. Carboniferous, Pepper Sandstones, Mugodjares, Turkestan, U.S.S.R.

Phillipsia inostranzewi Tolmachoff in Weber, 1937, p. 58, pl. vi, fig. 36. Carboniferous, Altai, Kuznetzk Basin, U.S.S.R.

Phillipsia elongata Mitchell, 1918, p. 456, pl. xlvii, figs. 3-5; pl. xlvii, figs. 3-5; pl. xlviii, fig. 14; pl. i, figs. 4-7. Carboniferous, Binge Berry, Rouchel Brook, Hunter River, Co. Durham; also ? Allyn River, half a mile north-east of Gresford, Co. Durham, New South Wales.

Phillipsia? waterhousei Mitchell, 1918, p. 455, pl. xlviii, figs. 16-18, pl. lii, fig. 7. Carboniferous. Probably Paterson or Dungog district, New South Wales.

Phillipsia sp.? Mansuy, 1913, p. 33, pl. v, figs. 6 a, b (cranidia); *Phillipsia* cf. *propinqua*, *ibid.*, pl. v, figs. 7 a-c. Lower Carboniferous, Nong-po Shales, Tran-ninh, French Indo-China.

REMARKS.—The generic characters of the thorax and pygidium of *Linguaphillipsia* are not known with certainty, though the pygidium figured by Weber (1937) for *L. tulensis* (Ivanow) is similar in plan to that tentatively assigned to the genotype species below; there is some doubt concerning the pygidium of *L.? collinsi*. The complete specimen referred to *Phillipsia collinsi* Mitchell (1918, pl. xlviii, fig. 9) was figured as having a pygidium differing from those in Mitchell's other illustrations of detached pygidia attributed to the same species, noticeably in the absence of the narrow border "furrow", and of the lines of tubercles which continue on the border the course of the pleural ridges; this difference may be due, however, to the original of Mitchell's fig. 9 having had its dorsal surface removed marginally. The isolated pygidia, nevertheless, resemble those of *P. kirgisica* Weber (1937, pl. v, figs. 43-6) which are found in structural continuity with a cephalon of the type seen in the genus *Cummingella* Reed (1942); in fact a somewhat similar pygidium occurs in *C. jonesi* (Portlock), which species' name has been stated erroneously by Woodward (1883, p. 14), and others to be a synonym of "*Phillipsia*" *derbyensis* (Martin). This last matter has lately been discussed in some detail (Stubblefield, 1946). Unfortunately the only complete specimen of *P. collinsi* figured by Mitchell shows, in the illustration, glabella features too obscure to be united convincingly in the same species as pl. xlviii, fig. 8, which last is here chosen as (the figure of) the lectotype of *L.? collinsi* (Mitchell).

P. elongata Mitchell has a pygidium which might be compared closely with the Malayan pygidium figured here as plate xiv, figs. 1 a, b, but in the Australian species the facial suture is more divergent anteriorly than is typical for *Linguaphillipsia*, and in this respect it is more like *Cyrtosymbole*, a resemblance which could also be noted with *P. kassini* Weber (1937, pl. ix, figs. 42-7, text-fig. 40) from the Kirghiz Steppe. Both these species, however, show greater pygidial segmentation than does *Cyrtosymbole*.

COMPARISON OF *Linguaphillipsia* WITH OTHER GENERA.—This genus differs from *Phillipsia* Portlock, as emended by Weller (1936) in the pronounced lateral expansion of the glabella posteriorly; the glabella shape recalls that seen in the Tremadoc genus *Apatokephalus* and certain of the Remopleurididae. The Lower Carboniferous forms of the genus *Cummingella* Reed, as well as the Pennsylvanian and Lower Permian species of the genus *Ameura* (Weller, 1936, 1937), show a similar postero-lateral expansion, but in these forms there is also an antero-lateral expansion of the glabella and the anterior border furrow loses its intensity.

The course of the facial suture and particularly the pre-ocular branches differentiate *Linguaphillipsia* from other Proetid genera, such as *Cyrtosymbole* R. Richter,¹ *Drevermannia* R. Richter, and *Typhloproetus* R. Richter, which sometimes have a glabella on the *Linguaphillipsia* plan. Even in R. and E. Richter's subgenus *Cyrtosymbole* (*Waribole*), which ranges from Upper Devonian to Lower Carboniferous, where the facial sutures diverge anteriorly at a lower angle than in *Cyrtosymbole* sensu stricto and in *C. (Calybole)*, the pre-glabellar field is longer than in *Linguaphillipsia*. A further distinction is that in all subgenera of *Cyrtosymbole*, the pygidial pleurae are furrowed, a feature not seen in any of the pygidia found associated with *Linguaphillipsia terapaiensis*, nor in any of the species assigned above to the genus.

The genus possibly evolved from some such species as the minute "*Cyrtosymbole*" *pusilla* (Gürich) from a high level in the Upper Devonian of Poland (Richter, 1913, p. 394, pl. xxii, figs. 31, 32; R. and E. Richter, 1926, pp. 61, 82, 292). Alternately, the form described as *Proetus indosinensis* Mansuy (1916, p. 23, pl. iii, figs. 16 b, c) from the ? Lower Devonian *Spirifer tonkinensis* horizon of Tonkin may have been on the evolutionary line, for here the pygidium does not have the characteristic *Cyrtosymbole* pleural divisions.

DISTRIBUTION.—As at present known *Linguaphillipsia* ranges from Siberia, central and southern Russia to Malaya, and also perhaps to eastern Australia. *Cyrtosymbole* seems to be in eastern Yunnan at Ta-Koa in the "Carboniférien inférieur à *Spirifer subconicus*" as *Proetus ellipticus* Mansuy (1912, pl. xvi, fig. 2 c); the genus is unrecorded from Malaya or Australia, but is known in Russia and elsewhere.

***Linguaphillipsia terapaiensis* sp. nov.**

(Pl. xiii, figs. 1-3; ? Pl. xiv, figs. 2, 3)

MATERIAL.—Two cranidia numbered **In. 38824**, **In. 38825**, one cephalon numbered **In. 38826**, all occurring as internal casts. Specimen, **In. 38824** (pl. xiii, fig. 1) has an external mould of a pygidium (pl. xiv, fig. 3) associated on the same slab.

LOCALITY AND HORIZON.—See under GENUS.

PARTIAL DIAGNOSIS.—Cranidium fairly large, about 11 mm. long and 19 mm. wide, acutely rounded anteriorly; surface apparently smooth, but with a slight median tubercle on the posterior margin of the occipital ring; marginal band in front of glabella flat or slightly convex; glabella well rounded anteriorly, with four pairs of glabellar furrows of which the most posterior pair reaches but overhangs the well-impressed occipital furrow. Ratio of glabellar length to breadth anteriorly, at the widest region and at the occipital furrow, is as 14 :: 9 : 12 : 11 in a glabella 7 mm. long; at the same glabellar length, median portion of glabella between the pre-occipital lobes is to the maximum glabellar width as 2 : 5.

HOLOTYPE.—Specimen numbered **In. 38824**: length, approximately 7.5 mm. (occipital ring not preserved).

PARATYPES.—Specimens numbered **In. 38825**, **In. 38826**.

DESCRIPTION.—Cephalon acutely rounded in front; ratio of breadth to length is as 19 : 11; marginal band in front of glabella flat or slightly convex, distinct, narrower than laterally as if glabella had encroached on to margin, band flat but ventrally inclined, laterally. Genal angles probably spinose. Glabella inflated, with four pairs of furrows; declined forwards from level of the palpebral lobes; rounded in front and narrowest anteriorly with forwardly converging sub-parallel sides for half the length which is as far as the furrows lying third beyond the occipital furrow, then expanding to reach a maximum width just behind the pre-occipital furrows, i.e. at mid-eye breadth; the axial furrows then curve in and down to reach the occipital furrow; the ratio of length to the respective breadths anteriorly, at the widest region and at the occipital furrow is as 14 :: 9 : 12 : 11 in a glabella about 7 mm. long; basal or pre-occipital lobes moderately large,

¹ Reed (1943, p. 63) referred his subgenus *Cyrtoproetus*, with its genotype *Phillipsia cracoensis* Reed to *Cyrtosymbole*; the pre-ocular branches of the facial sutures do not seem to be sufficiently divergent to permit this assignation, they have a course similar to that seen in *Linguaphillipsia* but the shape of the glabella, the presence of lateral lobes in the occipital ring and the furrowed pleurae of the pygidium are features which separate *Cyrtoproetus* from *Linguaphillipsia*.

basal or pre-occipital furrows originating at a level in front of middle of palpebral lobes and following a slightly curved course inwards, well-impressed and broadening in mid-course, then taking a sub-parallel or axial course for their posterior third to overhang the occipital furrow which is considerably more impressed; these pre-occipital furrows leave a region two-fifths the glabellar width between them at the maximum width; the three anterior furrow-pairs are progressively shorter furrows, the hindmost of these have an obliquely inclined backward course becoming well-impressed posteriorly and giving the pre-basal lobes a globular appearance; the middle or second of these three furrow-pairs occurs at about mid-glabellar length and is of more uniform depth; the foremost furrow-pair is obsolete towards the axial furrow, horizontal and short. Occipital ring short and of fairly even length, with a slight median tubercle on its posterior edge. Occipital furrow well impressed. Axal furrows well defined. The pre-ocular branch of the facial suture runs axally forwards, then bends slightly outwards to cross the border furrow as a straight line; at this furrow it takes a broad curve to meet the anterior margin in an acute angle leaving the pre-palpebral portions of fixed cheek very narrow in front of palpebral lobe, but more anteriorly of fairly uniform breadth, slightly wider opposite the antero-lateral angles of the glabella than elsewhere; the breadth across this portion of the fixed cheek being approximately equal to the maximum breadth of glabella; cephalic pores of average size. The palpebral lobe is a narrow crescent reaching from the point where the glabella widens almost to the occipital furrow. The post-ocular branch of the facial suture appears to be of normal Phillipsiid plan, cutting off a narrow sub-triangular piece of the occipital "pleura".

Eye raised, base defined by a sharp but shallow groove, at least laterally and posteriorly; marginal border wide and flat, postero-laterally sloping down and leaving at the side of the eye but a slight portion of the fixed cheek on the inner side of the wide but shallow border furrow laterally, posteriorly there is a sub-triangular area possibly with granulose ornament which slopes down to the shallow but wide pleur-occipital and lateral border furrows.

Pygidium not definitely known; the damaged pygidium (length approximately 6 mm.) on the same rock surface as the holotype, and illustrated on pl. xiv, fig. 3, has a broadly rounded hind-end and a smooth, concave border narrowing anteriorly; laterally there are probably eleven raised ribs with shallow angular furrows; the most anterior rib continues across the depressed border and judging from the cavity surrounding the cast, the shell was fairly thick.

REMARKS.—Of available illustrations, *L. terapaiensis* is probably closest to Weber's "*Phillipsia* sp., No. 3" (see above), but in the Turkestan form, the anterior lobe of the glabella is wider, the pre-basal lobe less globular, and the region between the basal lobes wider and perhaps more inflated than in the Malayan species. The glabella of *L. collinsi* (Mitchell) is more coarsely ornamented; that of *P. elongata* Mitchell more elongate and the pre-ocular branches of the facial suture more divergent.

? *Linguaphillipsia terapaiensis* sp. nov.

(Pl. xiv, figs. 2 a-c)

An internal cast of a pygidium (In. 38827) which, if complete, would measure approximately 10 mm. long and 13 mm. wide, may belong to *L. terapaiensis*. The axis is composed of fourteen or fifteen rings, more than one-third as wide as the pygidium anteriorly, narrowing behind to a blunt rounded but slightly raised termination. Crest of axis elevated, each ring rising to a ridge posteriorly: the most anterior ring with a ridge forming an even curve and continuing to the axal furrows; successive rings are flattened dorsally and steep-sided laterally, the ridge losing intensity as it descends to the axal furrow; the lateral slopes steepen posteriorly; ridges are probably tuberculate, particularly the fifth, sixth, and seventh from front. The furrows between the ridges in the internal cast occupy twice the space filled by the ridges. Pleural lobes rise from axal furrows to take a horizontal course, then, after passing rather more than half the width, fall obliquely downward; composed of twelve rounded ridges separated by rounded furrows of about equivalent dimensions. The most anterior ridge pairs approximately transverse, remainder progressively inclined backwards. The most anterior ridge appears to cross on to the border which continues the slope of ridged pleural lobes, but is slightly concave. The dorsal surface of

the border is partly preserved on the right-hand side as a smooth downward slope, but on the left side this has been removed and the ventral or doublure impression is exposed as a slightly concave brim with irregular discontinuous con-marginal markings.

"*Phillipsia*" sp.

(Pl. xiv, figs. 1 a, b)

There are two pygidia, one preserved in counterpart (In. 38829, In. 38830), but damaged posteriorly, which appear to belong to the same species. The more complete specimen, In. 38828, is preserved only as an internal cast with pyrites replacement postero-laterally. The pygidium is sub-parabolic in outline, and in the figured specimen 12 mm. long and 15 mm. wide; the axis is composed of seventeen rings about four-fifths as wide as the pygidium anteriorly, narrowing posteriorly, particularly after the tenth ring from the front, to end in a bluntly rounded termination, shortly before reaching the border; the crest of the axis is elevated, each ring rising to a ridge posteriorly which was perhaps tuberculated; the first three rings have an even curve, the successive rings flattened dorsally and steep-sided laterally; the ridges lose intensity as they descend to the axial furrows, but are perceptible to the furrow along most of the length except perhaps posteriorly; the furrows in the internal cast are wider than the ridges. Pleural lobes rise from the axial furrows to take a curved course with its summit half-way along the lobe (excluding the border) falling obliquely downwards, composed of twelve ridges with wide interspaces (on the internal cast), the most anterior ridge-pair crosses the border. The border is apparently concave and smooth. The shell thickness at the lateral border is probably 0.7 mm. anteriorly and 0.5 mm. posteriorly.

It has not been considered profitable to assign this pygidium to any particular genus or species, since it is of a generalized type; determination should await the finding of an associated cranidium. It may be that this is the adult pygidium of *L. terapaiensis*.

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XIII. EXPLANATION OF PLATES

All specimens are natural size unless otherwise stated.
B.M.=British Museum (Natural History).

PLATE I

- FIGS. All specimens are from the Visean of Sungei Terapai, Kuantan, Pahang, Malaya.
- 1 and 2.—*Echinoconchus elegans* (M'Coy). (1) Brachial valve, pedicle valve and inner layer of brachial valve removed. $\times 1\frac{1}{2}$ approx. B.M. [BB. 7909]. (2) Pedicle valve much crushed. $\times 1\frac{1}{2}$. B.M. [BB. 7911]. (Page 60.)
- 3.—*Chonetes* sp. Internal cast of pedicle valve showing diductor muscle-scars. $\times 1\frac{3}{4}$. B.M. [BB. 7914]. (Page 59.)
- 4 and 5.—*Schizophoria* sp. (4) Internal cast of pedicle valve, showing strong median septum, and diductor impressions. The fine costation is preserved anteriorly. $\times \frac{4}{5}$. B.M. [BB. 7975]. (5) Internal cast of brachial valve, showing curved slits representing brachio-phore plates. $\times 1\frac{1}{2}$ approx. B.M. [BB. 7973]. (Page 57.)
- 6 and 7.—*Leptaena* cf. *analoga* (Phillips). (6) Brachial valve, showing cardinal process and adductor muscle-scars posteriorly. B.M. [BB. 7904]. (7) Decorticated pedicle valve, showing slits representing median septum and hinge-teeth. B.M. [BB. 7903]. (Page 58.)
- 8.—*Productina* cf. *margaritacea* (Phillips). Pedicle valve, showing row of spine-bases on ears. $\times 1\frac{1}{2}$. B.M. [BB. 7908]. (Page 61.)
- 9.—Slab with *Punctospirifer pahangensis* sp. nov. and *Schizophoria* sp. $\times 2$. A, B=*Punctospirifer pahangensis*. A—Brachial valve with slit representing median septum. B—Specimen showing punctate shell. C, D=*Schizophoria* sp. C—Pedicle valve, showing long diductor scars between dental lamellae and median septum. D—Brachial valve, showing adductor muscle-scars. $\times 2$. B.M. [BB. 7974]. (Page 64.)

PLATE II

All specimens are from the Visean of Sungei Terapai, Kuantan, Pahang, Malaya.

- 1 to 3.—*Hustedia* cf. *radialis* (Phillips). (1) Internal cast of brachial valve, showing slit posteriorly representing short median septum. The median costa is enlarged. $\times 1\frac{1}{2}$. B.M. [BB. 7916]. (2) Pedicle valve, showing median incision and curving costae. $\times 1\frac{1}{2}$. B.M. [BB. 7922]. (3) Pedicle valve, showing finely punctate shell. $\times 1\frac{1}{2}$. B.M. [BB. 7915]. (Page 65.)
- 4.—*Chonetes* sp. Decorticated pedicle valve, showing traces of ornament anteriorly. $\times 1\frac{3}{4}$. B.M. [BB. 7912]. (Page 59.)
- 5 to 10.—*Punctospirifer pahangensis* sp. nov. (5) Paratypes. Upper specimen: impression of brachial valve, showing prominent concentric lamellose ornament. B.M. [BB. 7944] (see fig. 10). (6) Paratype. Brachial valve, showing alate variety. B.M. [BB. 7971]. (7) Paratype. Pedicle valve, showing high concave cardinal area and narrow delthyrium. $\times 1\frac{1}{2}$. B.M. [BB. 7943]. (8) Paratypes. Two pedicle valves, showing shallow median sinus, and slits representing short median septum and delthyrial supporting plates. $\times 1\frac{1}{2}$ approx. B.M. [BB. 7942]. (9) Holotype. Brachial valve, showing low rounded median fold. $\times \frac{4}{5}$. B.M. [BB. 7946]. (10) Upper specimen in fig. 5, enlarged to show concentric ornament. $\times 1\frac{1}{2}$. Page (64.)
- 11.—*Dictyoclostus* cf. *parvus* (Meek & Worthen). Pedicle valve, showing fine costation and scattered spine-bases. $\times \frac{4}{5}$. B.M. [BB. 7907]. (Page 60.)

- 12.—Specimen *A*=*Hustedia* cf. *radialis* (Phillips). Brachial valve, showing slit representing short median septum. *B*, *C*=*Punctospirifer pahangensis* sp. nov. *C* shows two valves in anterior view. B.M. [BB. 7947]. Specimens $\times \frac{4}{3}$. (Page 64.)

PLATE III

All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1 *a*, *b*.—*Linoproductus tenuistriatus* (de Verneuil). Bukit Charas, north end of hill (locality 5048). (1*a*) Lateral view of pedicle valve, showing concentric folds on flanks. (1*b*) Same specimen enlarged to show ornament on venter. $\times 1\frac{1}{2}$. B.M. [BB. 7888]. (Page 37.)
- 2.—Specimen *A*=*Linoproductus tenuistriatus* (de Verneuil), *B*=*Linoproductus kokdscharensis* (Gröber). Bukit Charas (locality 9904). *A*—Ventral valve, showing typical form and ornament. *B*—Imperfect pedicle valve, showing ornament. B.M. [BB. 7895]. (Page 37.)
- 3 and 4.—*Linoproductus kokdscharensis* (Gröber). Bukit Charas (locality 5048). (3) Imperfect pedicle valve, with one large ear preserved. B.M. [BB. 7870]. (4) Pedicle valve, showing finer ornament. B.M. [BB. 7861]. (Page 35.)
- 5 *a*, *b*.—*Linoproductus yunnanensis* (Loczy). Bukit Sagu. (5*a*) Ventral view of pedicle valve, showing steep flanks and produced trail. (5*b*) Lateral view of same valve, showing incurved umbo. No concentric folds are developed on lateral slopes. B.M. [BB. 7857]. (Page 34.)

PLATE IV

All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1 *a-c* and 2 *a-c*.—*Sinuatella orientalis* sp. nov. Bukit Sagu. (1) Paratype. B.M. [BB. 7844]. (1*a*) Pedicle valve, showing visceral disk and part of trail with shallow median sinus. The fine costation can be seen in places. (1*b*) Pedicle valve, showing trail. (1*c*) Lateral view of same valve. (2) Holotype. B.M. [BB. 7841]. (2*a*) Posterior view of brachial valve, showing concentric ribs. Fragment of hinge-tooth can be seen in one hinge-socket. $\times 1\frac{1}{2}$. (2*b*) Lateral view, showing fragment of trail of pedicle valve in contact with brachial valve anteriorly. (2*c*) Part of trail of pedicle valve seen in contact with trail of brachial valve. The remainder of pedicle valve and inner layer of brachial valve have split off. $\times 1\frac{1}{2}$. (Page 39.)
- 3 *a*, *b*.—*Buxtonia* sp. Bukit Sagu. (3*a*) Ventral valve, showing costation and two concentric bands bearing small spine-bases. (3*b*) Lateral view of same valve. B.M. [BB. 7850]. (Page 28.)
- 4 *a*, *b*.—*Schizophoria mesoloba* (Yanishevsky). Bukit Sagu. (4*a*) Imperfect dorsal valve with median sinus. (4*b*) Anterior view, showing episulcate commissure. B.M. [BB. 7832]. (Page 24.)
- 5.—*Gigantella* cf. *latissima* (J. Sowerby). Bukit Tinggik. Immature brachial valve. $\times 1\frac{1}{2}$. B.M. [BB. 7881]. (Page 32.)
- 6 *a*, *b*.—*Dictyoclostus* cf. *deruptus* (Romanowsky). Bukit Tinggik. (6*a*) Lateral view of ventral valve, showing fine costation. (6*b*) Same valve, showing shallow sinus and steep flanks. B.M. [BB. 7878]. (Page 30.)

PLATE V

All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1 *a*, *b*.—*Krotovia* cf. *keyserlingiana* (de Koninck). Bukit Tinggik. (1*a*) Ventral valve, showing ornament of spine-bases. $\times 2$. (1*b*) Lateral view of same valve. $\times 2$. B.M. [BB. 7856]. (Page 33.)
- 2.—*Dictyoclostus* sp. Bukit Sagu. Pedicle valve, showing visceral disk. The trail is not preserved in any specimen. B.M. [BB. 7854]. (Page 30.)

FIGS.

- 3.—*Linoproductus tenuistriatus* (de Verneuil). Bukit Charas, north end of hill (locality 5048). Brachial valve exposed by splitting off of pedicle valve and inner layer of brachial valve. B.M. [BB. 7887]. (Page 37.)
- 4.—*Krotovia multituberculata* (Yanishevsky). Bukit Sagu. Pedicle valve, showing spinose ornament. $\times 2$ approx. B.M. [BB. 7882]. (Page 32.)
- 5.—*Avonia weberi* (Yanishevsky). Bukit Sagu. Pedicle valve, showing spinose ornament posteriorly and costae developed on anterior part of shell. $\times 1\frac{1}{2}$. B.M. [BB. 7840]. (Page 28.)
- 6.—*Marginicinctus* ? cf. *planus* (Yanishevsky). Bukit Tinggik. Pedicle valve, showing marginal ledge anteriorly, and well-defined concentric ribs. $\times 2$. B.M. [BB. 7848]. (Page 40.)
- 7.—*Proboscidella nana* sp. nov. Bukit Sagu. Pedicle valve, showing short tubular trail. $\times 4$. B.M. [BB. 7839]. (Page 38.)
- 8.—*Avonia weberi* (Yanishevsky). Bukit Charas (locality 9904). Pedicle valve, showing spinose ornament. $\times 2$ approx. B.M. [BB. 7889]. (Page 28.)
- 9.—*Echinoconchus* sp. Bukit Tinggik. Lateral view of pedicle valve figured on plate ix, fig. 7. B.M. [BB. 7847]. (Page 31.)
- 10.—*Krotovia multituberculata* (Yanishevsky). Bukit Sagu. Pedicle valve. $\times 1\frac{1}{2}$. B.M. [BB. 7883]. (Page 32.)
- 11 a, b.—*Buxtonia* sp. Bukit Tinggik. (11a) Slightly distorted pedicle valve, showing ornament. $\times 1\frac{1}{2}$. (11b) Lateral view of same valve. $\times 1\frac{1}{2}$. B.M. [BB. 7851]. (Page 28.)
- 12.—*Avonia* cf. *davidsoni* (Jarosz). Bukit Sagu. Pedicle valve, showing spinose and costate ornament. $\times 1\frac{1}{2}$ approx. Associated with *Proboscidella nana* sp. nov. (fig. 7). B.M. [BB. 7839]. (Page 27.)

PLATE VI

All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1 a-d.—*Reticularia* cf. *alexandri* T. N. George. Bukit Sagu. (1a) Lateral view of both valves. (1b) Ventral valve, showing concentric ornament. (1c) Anterior view, showing acuminate linguiform extension. (1d) Dorsal view, showing part of brachial valve with prominent median fold. B.M. [BB. 7774]. (Page 54.)
- 2 a, b.—*Pugnax* cf. *pugnus* (Martin). Bukit Tinggik. (2a) Anterior view of imperfect pedicle valve. (2b) Dorsal view of same specimen. B.M. [BB. 7826]. (Page 43.)
- 3 a-c and 4 a-c.—*Pugnax asiaticus* sp. nov. Bukit Tinggik. (3) Holotype. B.M. [BB. 7825]. (3a) Lateral view. (3b) Anterior view. (3c) Dorsal view of imperfect specimen. (4) Paratype. B.M. [BB. 7823]. (4a) Lateral view. (4b) Anterior view, showing acuminate linguiform extension of pedicle valve. (4c) Dorsal view, showing shell lacking ornament. (Page 41.)
- 5 a, b and 6.—*Reticularia imbricata* (J. Sowerby). Bukit Sagu. (5a) Ventral view to show ornament. $\times 1\frac{1}{2}$. (5b) Dorsal view of same specimen. B.M. [BB. 7770]. (6) Detached dorsal valve, showing concentric lamellae. $\times 1\frac{1}{2}$. B.M. [BB. 7771]. (Page 53.)

PLATE VII

All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1 a-c and 3 a-c.—*Spirifer scrivenori* sp. nov. Bukit Sagu. (1) Holotype. B.M. [BB. 7793]. (1a) Lateral view. (1b) Anterior view, showing acuminate linguiform extension of pedicle valve. (1c) Dorsal view, showing median fold and ornament. $\times 1\frac{1}{2}$. (3) Paratype. B.M. [BB. 7794]. (3a) Dorsal view of incomplete specimen. (3b) Ventral view, showing deep and narrow sinus. (3c) Lateral view. (Page 50.)
- 2 a-d and 4.—*Neospirifer derjawni* (Yanishevsky). Bukit Sagu. (2a) Dorsal view of imperfect specimen asymmetrically developed. $\times 1\frac{1}{2}$. (2b) Lateral view. (2c) Anterior view, showing commissure. (2d) Ventral view, showing costae and fine concentric ornament. $\times 1\frac{1}{2}$. B.M. [BB. 7791]. (4) Ventral valve, showing grouping of costae in fascicles. $\times 1\frac{1}{2}$. B.M. [BB. 7789]. (Page 48.)

PLATE VIII

FIGS. All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1, 2, and 3 *a, b*.—*Brachythyris willbourni* sp. nov. (1) Paratype. Bukit Sagu. Brachial valve, showing ornament and rounded cardinal extremities. B.M. [BB. 7800]. (2) Paratype. Bukit Tinggik. Imperfect brachial valve. B.M. [BB. 7806]. (3) Holotype. Same locality as fig. 1. B.M. [BB. 7801]. (3*a*) Ventral valve, showing ornament. (3*b*) Lateral view of same valve. (Page 45.)
- 4 and 5.—*Spirifer* cf. *condor* d'Orbigny. Bukit Sagu. (4) Brachial valve, showing ornament and rounded median fold. B.M. [BB. 7814]. (5) Pedicle valve with broad shallow sinus. B.M. [BB. 7815]. (Page 49.)
- 6.—*Spirifer* sp. (*striatus* group). Bukit Charas (locality 5048). Imperfect brachial valve. B.M. [BB. 7817]. (Page 52.)
- 7.—cf. *Choristites*? *humerosus* (Phillips). Bukit Tinggik. Imperfect pedicle valve, showing ornament and broad sinus. B.M. [BB. 7816]. (Page 47.)

PLATE IX

All specimens from the Upper Visean of the Kuantan district of Pahang, Malaya.

- 1 *a, b*, and 2.—*Dielasma* cf. *attenuatum* (Martin). Bukit Sagu. (1*a*) Pedicle valve, showing small foramen. (1*b*) Lateral view of same valve, showing acutely tapering umbo. B.M. [BB. 7788]. (2) Imperfect pedicle valve lacking umbo, but showing outline of shell and truncated anterior margin. B.M. [BB. 7787]. (Page 56.)
- 3.—*Dielasma* sp. Bukit Sagu. Pedicle valve, showing massive umbo truncated by large foramen. B.M. [BB. 7786]. (Page 56.)
- 4 *a-c*.—*Brachythyris*? *buckmani* Yanishevsky. Bukit Sagu. (4*a*) Lateral view. (4*b*) Anterior view, showing uniplicate anterior commissure. (4*c*) Dorsal view of both valves. $\times 1\frac{1}{2}$. B.M. [BB. 7772]. (Page 44.)
- 5 *a-c* and 6 *a, b*.—*Stenosisma saguensis* sp. nov. (5) Holotype. B.M. [BB. 7827]. Bukit Sagu. (5*a*) Dorsal view. (5*b*) Anterior view showing highly arched commissure. (5*c*) Lateral view. (6) Paratype. B.M. [BB. 7828]. Bukit Tinggik. (6*a*) Lateral view of the two valves in which the median septum of the pedicle valve is exposed in contact with spondylium. The median septum of the brachial valve is just distinguishable. $\times 1\frac{1}{2}$. (6*b*) Reverse view of same specimen, showing external characters. (Page 26.)
- 7.—*Echinoconchus* sp. Bukit Tinggik. Pedicle valve. $\times 2$ approx. B.M. [BB. 7847]. (Page 31.)
- 8 and 9.—*Phricodothyris* sp. Bukit Sagu. (8) Dorsal view, showing ornament. $\times 2$ approx. B.M. [BB. 7777]. (9) Dorsal view of two valves. $\times 2$ approx. B.M. [BB. 7776]. (Page 52.)

PLATE X

Figs. 1 to 3.—Plant remains from the Lower Carboniferous, Sungei Terapai, Pahang, Malaya.

Figs. 4 to 6.—Brachiopods.

- 1.—*Lepidodendron*. Part of a small forking branch; below is a fragment of *Stigmara*. B.M. [V. 26802]. (Page 78.)
- 2.—*Lepidodendron*. Showing the obscure leaf-bases. $\times 2$. B.M. [V. 26803]. (Page 78.)
- 3.—Decorticated lepidodendroid axis. B.M. [V. 26804]. (Page 78.)
- 4 to 6.—*Brachythyris kokuensis* Dikareva. Lower Carboniferous, Upper Visean, Bukit Sagu, Kuantan, Pahang, Malaya. (4) Part of pedicle valve, showing coarse costation and shallow median sinus. B.M. [BB. 7818]. (5) Detached brachial valve. B.M. [BB. 7821]. (6) Part of a large pedicle valve with coarse costation. B.M. [BB. 7819]. (Page 44.)

PLATE XI

- 1.—*Fenestella* cf. *tenax* Ulrich. Squeeze from mould of non-poriferous (reverse) surface of zoarium. $\times 5$. Visean shale, Sungei Terapai, Pahang. B.M. [D. 36433]. (Page 88.)

FIGS.

- 2.—*Fenestella* cf. *angustata* (Fischer v. Waldheim). Squeeze from mould of non-poriferous (reverse) surface of zoarium. $\times 5$. Visean shale, Sungei Terapai, Pahang. B.M. [D. 36442]. (Page 87.)

PLATE XII

- 1.—*Fenestella* cf. *polyporata* (Phillips). Mould of non-poriferous (reverse) surface of zoarium. $\times 2$. Visean shale, Sungei Terapai, Pahang. B.M. [D. 36438]. (Page 88.)
 2.—*Anthraconeilo* aff. *taffiana* Girty. Right valve. Visean shale, Sungei Terapai, Pahang. B.M. [PL. 420]. (Page 90.)
 3.—? *Solemya* sp. Left valve. Upper Visean limestone. Bukit Sagu, Pahang. B.M. [PL. 419]. (Page 83.)
 4.—*Streblopteria* sp. Right valve. Upper Visean limestone. Bukit Tinggik, Pahang B.M. [PL. 412]. (Page 84.)
 5.—*Pterinopectinella* cf. *granosa* (J. de C. Sowerby). Left valve. Upper (?) Visean limestone. Bukit Charas (locality 5048), Pahang. B.M. [PL. 418]. (Page 83.)
 6.—*Orthomychia* sp. Lateral aspect. $\times 2$. Upper Visean limestone. Bukit Sagu, Pahang. B.M. [PG. 875]. (Page 85.)

PLATE XIII

All specimens magnified approximately four times, and all from Sungei Terapai, Pahang, Malaya.

- 1.—*Linguaphillipsia terapaiensis* gen. et sp. nov. Holotype, internal cast of cranidium, slightly distorted, shows fixed cheek on right side. B.M. [In. 38824]. (Page 99.)
 2.—*Linguaphillipsia terapaiensis* gen. et sp. nov. Paratype, internal cast of cranidium, compressed dorso-ventrally, showing occipital ring. B.M. [In. 38825]. (Page 99.)
 3.—*Linguaphillipsia terapaiensis* gen. et sp. nov. Paratype, internal cast of damaged cephalon, showing free cheek in position on right side and course of facial suture. B.M. [In. 38826]. (Page 99.)

PLATE XIV

All specimens magnified approximately four times, and all from Sungei Terapai, Pahang, Malaya.

- 1 *a, b*.—"Phillipsia" sp. Internal cast of pygidium, dorsal and lateral view. B.M. [In. 38828]. (Page 101.)
 2 *a-c*.—"Linguaphillipsia terapaiensis. Internal cast of pygidium, dorsal, lateral, and hind views. B.M. [In. 38827]. (Page 100.)
 3.—? *Linguaphillipsia terapaiensis*. Damaged external mould of pygidium on same rock slab as holotype of *L. terapaiensis*. B.M. [In. 38824]. (Page 99.)

PLATE XV

- 1.—*Lithostrotion* {*Diphyphyllum*} sp. Longitudinal section. $\times 6$. Dissepimentarium partly restored. Lower Carboniferous, Visean. Bukit Charas, Pahang, Malaya. B.M. [R. 19106]. (Page 94.)
 2.—*Amygdalophyllum* sp. Transverse section. $\times 6$. Neanic stage. Lower Carboniferous, Visean, Bukit Tinggik, Pahang, Malaya. B.M. [R. 34005]. (Page 94.)
 3.—*Amygdalophyllum* sp. Transverse section. $\times 6$. Ephebic stage. Lower Carboniferous, Visean. Bukit Charas, Pahang, Malaya. B.M. [R. 19101]. (Page 94.)
 4.—*Amygdalophyllum* sp. Longitudinal section. $\times 6$. Reconstructed. (Page 94.)

PLATE XVI

FOSSIL LOCALITIES IN MALAYA

- 1.—Uralian. Quartzite with *Fusulina*, bryozoa, etc. Goa Laman Maling, Perlis.
 2.—Permian. Limestone with brachiopods and gastropods. Bukit Taming, Perlis.

- 3.—Uralian. Silicified limestone with *Fusulinella*. Bukit Chuping, Perlis.
- 4.—Uralian. Limestone with crinoids, gastropod, etc. Langkawi I.
- 5.—Middle Trias. Shale with *Halobia*. Kuala Nerang, Kedah.
- 6.—Middle Trias. Shale with *Halobia*. Kampong Kuala, Kedah.
- 7.—Middle Trias. Shale with *Halobia*. Putus Semanggol, near Taiping, Perak.
- 8.—Carboniferous or Permian. Limestone with crinoid stems. Changkat Pari, near Ipoh, Perak.
- 9.—Carboniferous or Permian. Limestone with crinoid stems. Perak.
- 10.—Carboniferous or Permian. Limestone with crinoid stems. Kinta, Perak.
- 11.—Stephanian. Shale with *Pecopteris* and *Cordaites*. Sungei Chiku, near Kuala Nenggiri, Kelantan.
- 12.—Trias. Sungei Kelubi, near Gunong Tahan, Kelantan.
- 13.—Tertiary Coal Measures with plants. Rantau Panjang Forest Reserve, Selangor.
- 14.—Lower Carboniferous. Visean. Limestone with cephalopods. Old Punjom Concession, near Kuala Lipis, Pahang.
- 15.—Upper Trias. Sandstone with *Myophoria*. Fish remains. Sungei Lipis, and near Kuala Lipis, Pahang. (Several outcrops.)
- 16.—Upper Permian. Shale with *Xenodiscus* and *Dentalium*. Lubok Sukum, near Kuala Tembeling, Pahang.
- 17.—Trias. Fossil wood. Jerantut, Pahang. Also Upper Trias. Sandstone with *Myophoria*. Near Jerantut, Pahang.
- 18.—? Trias. Chert pebbles with plant remains. Sungei Tekai, tributary of Sungei Tembeling, Pahang. Age doubtful.
- 19.—Upper Trias. Sandstone with *Myophoria*. Near Temerloh, Pahang.
- 20.—Lower Carboniferous, Visean. Limestone with corals, brachiopods, etc. Bukit Charas, near Pasir Kamudi, Pahang.
- 21.—Lower Carboniferous, Visean. Limestone with brachiopods, etc. Bukit Sagu, Pahang.
- 22.—Lower Carboniferous, Visean. Limestone with brachiopods, etc. Bukit Tinggik, Pahang.
- 23.—Lower Carboniferous, Visean. Shale with brachiopods, trilobites, plants, etc. Sungei Terapai, Pahang.
- 24.—Upper Permian. Shale with brachiopods, bryozoa, etc. Sungei Jemeru, Kuala Lipis, Pahang.
- 25.—Upper Trias. Shale with *Myophoria*. Sungei Taba, near Raub, Pahang.
- 26.—? Jurassic. Clay with mollusca and plant remains. Mount Guthrie, Singapore.
- 27.—Upper Trias. Sandstone with *Myophoria*. Morse Road, Mount Faber, Singapore.
- 28.—Age uncertain. Chert with radiolaria. Singapore.
- 29.—Tertiary, ? Upper Miocene. Freshwater shale with *Viviparus*. Bore-hole, Durian Chandong, Kepong, Jahore.

PLATE XVII

Map showing probable distribution of sea (stippled) and land in Lower Carboniferous (Visean) times.

Localities of marine Visean.

- 1.—Kuantan, Pahang, Malaya.
- 2.—Patalung, Siam.
- 3.—Upper Menam Valley, Siam.
- 4.—Tran-ninh and Luang Prabang, Laos, Indo-China.
- 5.—Haiphong, Tonkin, Indo-China.
- 6.—Ta-shih-wo, West Yunnan.
- 7.—Tung-Shan, Chang-Yi, East Yunnan.
- 8.—Er-Ma-Tsung, Weining, Kweichow, China.
- 9.—Nanling Mountains, Kweichow and Kwangsi.
- 10.—Central Hunan.
- 11.—Tsinling Mountains, Shensi.
- 12.—Nanking Hills, Kiangsu.

- 13.—Omi-mura, Echigo, Japan.
- 14.—Cho-Niu-Kou, Wu-Wei-Hsien, Kansu, China.
- 15.—Nan-Shan Range, Sinkiang, and Kansu.
- 16.—Bardoun River, tributary of River Edsin-gol, Mongolia.
- 17.—Sair-Usu, Mongolia.
- 18.—Kuznetzk Basin, Tomsk, Siberia.
- 19.—Tomsk, Siberia.
- 20.—Semipalatinsk, Siberia.
- 21.—Bogdoola Range and Chol-Tau Mountains, Sinkiang.
- 22.—Yuldus Valley, Dzungaria.
- 23.—Barlyk Mountains, Tian-shan.
- 24.—Kuldja, Tian-shan.
- 25.—Dzungaria Alatau Range, Tian-shan.
- 26.—Khalyk-Tau Range, Tian-shan.
- 27.—Khan Tengri Mountains, Tian-shan.
- 28.—Utsch-turfan and Basch-tschakma, Tian-shan.
- 29.—Kok-schal-Tau Range, Tian-shan.
- 30.—Karkara, Tian-shan.
- 31.—Lake Issyk-kul, Tian-shan.
- 32.—Kashgar, Sinkiang.
- 33.—Narynsk, Tian-shan.
- 34.—Lake Son-kul, Tian-shan.
- 35.—Alai Mountains, Ferghana.
- 36.—Osh, Ferghana.
- 37.—Margelan, Ferghana.
- 38.—Kokand, Ferghana.
- 39.—Chatkal Mountains, Ferghana.
- 40.—Dzezkaqzan and Karsakpay, Kazakhstan.
- 41.—Kara-Tau Range, Kazakhstan.
- 42.—Kasy-kourt Range, Tchimbkent, Kazakhstan.
- 43.—Ishim River, Kazakhstan.
- 44.—Khorasan, Iran.
- 45.—Elburz Mountains, Iran.
- 46.—Shah Abdul Azim Mountains, south-east of Teheran, Iran.
- 47.—Araxes Gorge, west of Djoulfa, Armenia.
- 48.—Ante-Taurus Mountains, Asia Minor.
- 49.—Taurus Mountains, Asia Minor.
- 50.—Eregli [Heraclea], Asia Minor.
- 51.—Schartymka River, tributary of River Tobol, south of Miask, western Ural Mountains.
- 52.—Eastern Ural Mountains.
- 53.—Novaya Zemlya.
- 54.—Donetz Basin.
- 55.—Moscow Basin.

Marine Visean localities yielding plant debris.

- 1.—Sungei Terapai, Kuantan, Pahang, Malaya.
- 7.—Chang-Yi district of Yunnan (Hsin Tung, Chiu Lung Shan, and Hill O).

Plant localities of uncertain age, possibly Lower Carboniferous.

- 56.—(a) West of Liangtzeshang, Kützing, Yunnan.
 (b) North of Tahsuan'ang, Sunming, Yunnan.
 (c) East of Fangmach'iao, Kunming, Yunnan.
- 57.—North of P'osi station, Lih sien, Yunnan.
- 58.—Minussinsk Basin, Siberia.

INDEX

The page numbers of the Principal References are printed in clarendon type.

- abaeum, "Angaropteridium", 79
 aculeatus, Productus, 27, 33
cf. aculeatus, Productus, 33, 34
 acuminata, Rhynchonella, 43
 "Rhynchonella", 43
 acuminatus, Anomites, 41
 Pugnax, 13-15, 17, 41-3
 acuminatus *var.* klenovi, Pugnax, 42
 acutiloba, Reticularia, 55
 alexandri, Reticularia, 54
cf. alexandri, Reticularia, 8, 10, 15, 16, 54, 55
 amarginata?, "Phillipsia", 98
 Ameura, 98
 Amygdalophyllum, 10, 20, 94
 etheridgei, 9, 10, 94, 95
 inopinatum, 9
 nantanense, 9
 quiringi, 9
sp., 8, 9, 93, 94, 95
 thomsoni, 9
 wangi, 9
 analoga, "Plectambonites" rhomboidalis *var.*, 59
 Strophomena rhomboidalis *var.*, 58
 Leptaena rhomboidalis *var.*, 59
 Leptaena, 15, 18, 58, 59
 Producta, 58
cf. analoga, Leptaena, 8, 17, 58, 59
 Anelasma varians, Spirifer, 47
 "Angaropteridium" abaeum, 79
 angustata, Fenestella, 87, 88
 Retepora, 87
cf. angustata, Fenestella, 8, 87
 Anomia, 87
 Anomites acuminatus, 41
 attenuatus, Conchylolithus, 56
 giganteus, 32
 pugnus, Conchylolithus, 43
 punctatus, 31
 resupinatus, Conchylolithus, 24
 semireticulatus, 30
 Anthraconeilo, 90, 91
 taffiana, 90, 91
aff. taffiana, 8, 90
 antiquatus group, Dictyoclostus, 31
 Apatokephalus, 98
 arctica, Camerophoria rhomboidea *var.*, 27
 arysica?, Phillipsia kasakensis *var.*, 98
 ashfelliensis, Punctospirifer scabricostus *mut.*, 18, 65
 asiaticus *sp. nov.*, Pugnax, 8, 13-15, 17, 41, 42, 43
 Astero calamites, 78
 scrobiculatus, 79
 Athyrid, 8
 Athyris royssii, 55
 attenuatum, Dielasma, 56
cf. attenuatum, Dielasma, 8, 10
 attenuatus, Conchylolithus Anomites, 56
 Aulina, 12
 horsfieldi, 94
 Aviculopecten granosus, 83
 Avonia, 27, 33
 davidsoni, 27, 28
cf. davidsoni, 8, 10, 27
 karpinskianus, Productus, 28
 multituberculatus, Productus, 32
 tuberculatus, Productus, 55
 weberi, 8, 10, 15, 28
 Productus, 28
 baschsugensis, Schizophoria resupinata *var.*, 15
 bellerophonid gastropod, 3
 beschewiana, Reticularia, 16, 55
 beushauseni, Sinuatella, 40
 billingsi, Punctospirifer?, 63
 bisulcatiformis, Choristites *ex. gr.*, 14
 bisulcatus, Spirifer, 14-16, 36, 45-47
 bisulcatus?, Spirifer, 14, 36
 bitumulata, Phillipsia, 98
 bollandensis, Spirifer, 51
 Brachythyris, 44
 buckmani, 8, 15
 ? buckmani, 44
 integricosta, 47
 koksuensis, 8, 15, 44
 ovalis, 46, 47
 pinguis, 46
sp., 8
 suborbicularis *mut.* koksuensis, 44, 45
 subrotundata, 45, 46
aff. varians, 47
 willbourni *sp. nov.*, 8-10, 14-16, 45, 46, 47
 buckmani, Brachythyris, 8, 15, 44
 ? buckmani, Brachythyris, 44
 Buxtonia, 28, 30, 41
 scabricula, 16, 29
sp., 8, 10, 28, 29
 Calamites, 11
 Calybole, Cyrtosymbole, 99
 cambodgiensis, Spiriferina, 64
 Camerophoria, 26
 donica, 27
 rhomboidea, 27
 [=Stenoscisma], 26
var. arctica, 27
 verneuilliana, 27
 "Campophyllum *aff.* murchisoni", 93
 Cancrinella *sp.*, 10
 Caninia, 8, 93
 cylindrica, 93
 gigantea, 93
 near gigantea, 8, 93
sp., 8
 Caninia zone, 12
 "Caragandites rugosus", 78
 Cardiopteridium, 79
 carinatus, Spirifer, 51
 carteri, 'Saccamina', beds, 21

- Chaetetes *sp.*, 3
 Chonetes, 18, **59**, 97
 sp., 8, 17, **59**
 variolata, 59
 Choristites, **47**, 48
 ex. gr. bisulcatiformis, 14
 cf. Choristites?, 10
 cf. humerosus, 8, 10, **47**
 mosquensis, 47
 [? *Choristites*] *humerosus*, *Spirifer*, 13
 Cleiothyridina, **55**
 roissii, 55
 sp., 8, 36, **55**
 colei, *Phillipsia*, 98
 collinsi, *Linguaphillipsia*?, 98, 100
 Phillipsia?, 98
 Conchita *rhomboidalis*, 58
 Conchylolithus *Anomites attenuatus*, 56
 resupinatus, 24
 pugnis, 43
 concinnus, *Productus*, 30
 condor, *Spirifer*, 17, 49, 50
 cf. condor, *Spirifer*, 8, 15, 17, **49**, 50, 52
 connivens, *Schizophoria*, 25
 cora, *Linoproductus*, 35
 Productus, 34
 var. kokdscharensis, *Productus*, 35
 var. tenuistriatus, *Productus*, 37
 cf. cora var. kokdscharensis, *Productus*, 35
 Cordaites *sp.*, 4, 108
 corrugatus, *Linoproductus*, 35, 36, 38
 cracoensis, *Phillipsia*, 99
 cristata, *Spiriferina*, 65
 Cummingella, 98
 jonesi, 98
 Cyathaxonia *dissimilis*, 36
 sp., 94
 cf. cyathea, *Pecopteris*, 4
 Cyathocrinus?, 3
 cylindrica, *Caninia*, 93
 Siphonophyllia, 93
 Cyrtina? *sp.*, 15, 50
 Cyrtoceras, 4, 6
 Cyrtoproetus, 99
 Cyrtosymbole, 98, 99
 "Cyrtosymbole" *pusilla*, 99
 Cyrtosymbole (*Calybole*), 99
 (*Waribole*), 99
 Cystodictya, **90**
 sp., 8, 17, **90**
 Cystophrentis *zone* (= *Zaphrentis zone*), 12

 davidsoni, *Avonia*, 27, 28
 Productus youngianus var., 27
 cf. davidsoni, *Avonia*, 8, 10, **27**
 "Demetria", 79
 Dentalium, **85**, 86, 108
 cf. herculea, 4
 ? "Dentalium" *sp.*, 8, **85**
 derbyensis, "Phillipsia", 98
 derjawni, *Neospirifer*, 8, 10, **48**, 49
 Spirifer, 14, 15, 48, 49
 deroissii, *Spirifer*, 55
 deruptus, *Dictyoclostus*, 31
 Productus, 14, 30, 31
 cf. deruptus, *Dictyoclostus*, 8, 14, 17, **30**

 Dibunophyllum *zone*, 4, 10, 12, 22, 36, 40, 48, 93
 Upper, 14
 Dictyoclostus, **30**, 41, **60**
 antiquatus group, 31
 deruptus, 31
 cf. deruptus, 8, 14, 17, 30
 hindi, 31
 hindi var. wettonensis, 31
 muricatus, 60
 group, 8
 parvus, 60
 cf. parvus, 8, 17, 18, **60**
 sp., 8, 10, 15, 30
 Dielasma, **56**
 attenuatum, 56
 cf. attenuatum, 8, 10, **56**
 hastata, 57
 sp., 8, 11, **56**
 Diphyphyllum, **94**
 Lithostrotion, **94**
 sp., 8, **94**
 dissimilis, *Cyathaxonia*, 36
 Doliolina *cf. lepida*, 3
 donica, *Camerophoria*, 27
 dorsosinuata, *Schizophoria resupinata var.*, 25
 Drevermannia, 99
 duplicicosta, *Spirifer*, 50
 duplicicostus, *Spirifer*, 10, 15, 51

 Echigophyllum, 9, 20
 Echinoconchus, **31**, **60**, 61
 elegans, 8, 15, 18, **60**, 61
 sp., 8, **31**
 venusta, *Pustula*, 31
 edelburgensis, *Gigantella*, 12, 15, 16, 22
 Productus, 14, 36
 giganteus var., 22
 Edmondia, **82**
 sp., 8, **82**, 83
 elegans, *Echinoconchus*, 8, 15, 18, **60**, 61
 Producta, 60
 Productus, 60
 punctatus var., 60
 Pustula, 60
 elliptica, *Reticularia*, 15, 55
 ellipticus, *Proetus*, 99
 elongata, *Phillipsia*, 98, 100
 elongatus, *Terebratulites*, 56
 Eomarginifera *sp.*, 8
 equilatera, *Orthonychia*, 85
 etheridgei, *Amygdalophyllum*, 9, 10, 94, 95
 Eumetria *cf. grandicosta*, 67
 Euomphalus, 3

 fasciger, *Neospirifer*, 49
 Spirifer, 48
 Fenestella, **87**
 angustata, 87, 88
 cf. angustata, 8, **87**
 plebeia (Holotype), 89
 plebeia var. longifenestra, 89
 aff. plebeia, 8, **89**, 90
 cf. plebeia, 89
 polyporata, 88, 89
 cf. polyporata, 8, **88**
 cf. retiformis, 3

Fenestella rudis, 89
spp., 17
 tenax, 88
aff. tenax, 88
cf. tenax, 8, 88
 Fenestella Beds, 30
 Series, 13
 Shales, 13
 Fistulipora, 87
 sp., 8, 17, 87
 ? furcillatum, Sphenopteridium, 79
 Fusulina, 11, 107
 granum-avenae, 3
 Fusulinella konnoi, 3, 108

 gaablauensis, Sinuatella, 40
 gibbera, Schizophoria, 25
 gigantea, Caninia, 93
 Caninia *near*, 8, 93
 Gigantella, 11, 12, 15
cf. gigantea, Gigantella, 13
 Gigantella, 12, 32, 36
 edelburgensis, 12, 15, 16, 22
 gigantea, 11, 12, 15, 16
 cf. gigantea, 13
 latissima, 15, 16, 22
 aff. latissima, 32
 cf. latissima, 8, 10, 15, 32
 giganteus, Anomites, 32
 Productus, 11, 14, 15, 20, 36, 43, 79
 Productus, *beds*, 16, 21, 22
 var. edelburgensis, 22
cf. giganteus, Productus, 21
 Gigantopteris *flora*, 20
 Glossopteris *flora*, 5, 20
 grandicosta, Hustedia, 66
cf. grandicosta, Eumetria, 67
 granosa, Pterinopectinella, 83, 84
cf. granosa, Pterinopectinella, 8, 83
 granosus, Aviculopecten, 83
 Pecten, 83
 Pterinopecten, 83
 granum-avenae, Fusulina, 3
 Gyroceras, 4

 Halysites wallichi, 2
 hastata, Dielasma, 57
 Heliolites porosus, 2
 hemispherica, Streblopteria, 85
cf. herculea, Dentalium, 4
 horsfieldi, Aulina, 94
 hindi, Dictyoclostus, 31
 var. wettonensis, 31
 hudsoni, Schizophoria, 25
 humboldti, Productus [Waagenoconcha], 30
 humerosa, Spirifer, 47
 humerosus, *cf.* Choristites, 47
 Choristites ?, 10
 Spirifer, 47, 48
 ? humerosus, Spirifer [Choristites], 13
cf. humerosus, Choristites, 8
 Hustedia, 18, 65, 66, 67, 97
 grandicosta, 66
 mormoni, 66
 multiplicata, 67
 nasuta, 66
 8

Hustedia pelargonium, 66
 radialis, 66, 67
 Retzia, 15
aff. radialis, 66
cf. radialis, 8, 17, 65, 66, 67
 remota, 66

 imbricata, Reticularia, 8, 10, 13, 53, 54
 Terebratula, 53
 impersonata, Productus scabriculus *var.*, 29
 indosinensis, Proetus, 99
 inopinatum, Amygdalophyllum, 9
 inostranzewi, Phillipsia, 98
 integricosta, Brachythyris, 47
aff. integricosta *ex. gr.* pinguis, Spirifer, 47
aff. integricosta, Spirifer, 16, 47
 irregulare, Lithostroton, 36

 jonesi, Cummingella, 98
 juresanensis, Juresania, 29
 Juresania, 30
 juresanensis, 29

 Kansuella, 12
 karpinskianus, Productus [Avonia], 28
 kasakensis, Phillipsia, *var.* arysica ?, 98
 kassini, Phillipsia, 98
 kellii, Phillipsia, 97
 kentuckyensis, Punctospirifer, 63, 65
 keyserlingiana, Krotovia, 33
cf. keyserlingiana, Krotovia, 8, 10, 33
 keyserlingianus, Productus, 33
 [Krotovia], 16
 kirgisica, Phillipsia, 98
 klenovi, Pugnax acuminatus *var.*, 42
 kokdscharensis, Linoproductus, 8, 9, 12, 14, 15,
 35, 36
 Productus, 13, 35, 36
 cora *var.*, 35
 kokuensis, Brachythyris, 8, 15, 44
 suborbicularis *mut.*, 44, 45
 Koninckophyllum, 9
 konnoi, Fusulinella, 3
 Krotovia, 32, 33
 keyserlingiana, 33
 cf. keyserlingiana, 8, 10, 33
 keyserlingianus, Productus, 16
 multituberculata, 8, 10, 15, 32, 33
 cf. multituberculata, 11
 spinulosa, 15, 33
 spinulosus, Productus, 11
 kumpani, "Pseudomonotis", 85
 kutorgae, Proboscidea, 41
 kuzneciana ?, "Phillipsia" laticaudata *var.*, 97

 laevigata, Streblopteria, 85
 laminosa, Spiriferina, 18
 "Spiriferina", 63
cf. laminosa, Tylothyris, 11
 laticaudata *var.* kuzneciana ?, "Phillipsia", 97
 latissima, Gigantella, 15, 16, 22, 32
aff. latissima, Gigantella, 32
cf. latissima, Gigantella, 8, 10, 15, 32

- latissimus, *Productus*, 16, 32, 43
 latus, *Punctospirifer*?, 63, 65
 leeianum, *Lepidodendron*, 78
cf. lepida, *Doliolina*, 3
Lepidodendroids, 78
Lepidodendron, 22, 78-80
 leeianum, 78
 mirabile, 78
 sp., 8, 78, 79
Lepidodendropsis, 78
 flora, 80
Leptaena, 4, 10, 18, 58, 59, 97
 analoga, 15, 18, 58, 59
 cf. analoga, 8, 17, 58, 59
 rhomboidalis var. analoga, 59
 semibugensis, 59
 sinuata, 18, 39, 58
Leptodus [*Lyttonia*] *cf. tenuis*, 5
lian Chowensis, *Spirifer*, 12
lineata, *Phricodothyris*, 53
 Reticularia, 10, 53
Linguaphillipsia gen. nov., 97, 98, 99
 terapaiensis sp. nov., 8, 97, 99, 100, 101
 tulensis, 98
Linguaphillipsia? *collinsi*, 98, 100
 ? *Linguaphillipsia terapaiensis sp. nov.*, 100
Linoproductus, 34, 41
 cora, 35
 corrugatus, 35, 36, 38
 kokdscharensis, 8, 9, 12, 14, 15, 35, 36
 ovatus, 38
 tenuistriatus, 8, 11, 12, 15, 17, 37, 38
 "*tenuistriatus*", 14, 15, 17
 yunnanensis, 8, 12, 17, 34, 35, 36
Lithostroton, 94
 irregulare, 36
Lithostroton {*Diphyphyllum*}, 94
 sp., 8, 94
lobata, *Reticularia*, 55
logani, *Spirifer*, 16, 51
longifenestra, *Fenestella plebeia var.*, 89
 "*Lophiodendron*", 79
lucerna, *Phricodothyris*, 52
lutugini, *Spirifer*, 16, 51, 52
Lyttonia cf. tenuis, *Leptodus*, 5
- malevkaensis, *Punctospirifer*, 63, 65
marcoui, *Spirifer*, 51, 52
margaritacea, *Productina*, 8, 18, 62
 Productus, 61
cf. margaritacea, *Productina*, 61
margaritaceus, *Productus*, 15, 36, 61, 62
 group, *Productus*, 61
cf. margaritaceus, *Productus*, 62
 Thomasina, 62
Marginicinctus, 40, 41
 planus, 15
 ? *cf. planus*, 8, 40
marginicinctus, *Productus*, 40, 41
Marginifera sp., 5, 10
mesogonus, *Pugnax*, 42
mesoloba, *Schizophoria*, 8, 10, 15, 16, 24, 25, 57
mesolobus, *Orthis*, 24
mirabile, *Lepidodendron*, 78
molleri, *Spiriferina*, 63
mormoni, *Hustedia*, 66
 Terebratula, 65
- mortonanus*, *Spirifer*, 50
mosquensis, *Choristites*, 47
cf. mosquensis, *Spirifer*, 10
multicostatus, *Punctospirifer*, 63, 65
multiplicata, *Hustedia*, 67
multituberculata, *Krotovia*, 8, 10, 15, 32, 33
cf. multituberculata, *Krotovia*, 11
multituberculatus, *Productus* (*Avonia*), 32
 "*aff. murchisoni*, *Campophyllum*", 93
muricatus, *Dictyoclostus*, 60
 group, *Dictyoclostus*, 8
Myriopora?, 3
- nana sp. nov.*, *Proboscidea*, 8, 15, 38, 39
nantanense, *Amygdalophyllum*, 9
nasuta, *Hustedia*, 66
Neospirifer, 47
 derjawni, 8, 10, 48, 49
 fasciger, 49
northi, *Punctospirifer*, 63
Nucula, 91
Nuculana, 91
Nuculopsis, 91
nuda, *Schizophoria*, 25
nystianus, *Productus*, 39
- Omphalotrochus Kalk*, 51
orientalis sp. nov., *Sinuatella*, 8, 10, 39, 40
 ? *Orionastraea*, 16
Orthis mesolobus, 24
Orthoceras, 4, 6
Orthonychia, 85
 equilatera, 85
 parasitica, 85
 sp., 8, 85
orthotetid, 3
Orthothetina, 3
Ovalia, 44
ovalis, *Brachythyris*, 46, 47
 Spirifer, 44
ovata, *Rhacopteris*, 79
ovatus, *Linoproductus*, 38
- pahangensis sp. nov.*, *Punctospirifer*, 8, 11, 18, 64, 65
Palaeocapulus, 85
Palaeoneilo, 91
palliat, *Schizophoria*, 25
parasitica, *Orthonychia*, 85
partita, *Spiriferina*, 65
partitus, *Punctospirifer*, 63, 65
parvulus, *Productus*, 61
parvus, *Dictyoclostus*, 60
cf. parvus, *Dictyoclostus*, 8, 17, 18, 60
 Productus, 60
Pecopteris, 11, 108
 cf. cyathea, 4
Pecten granosus, 83
pelargonium, *Hustedia*, 66
peracuta, *Spiriferina*, 63
periculosa, *Phricodothyris*, 53
Phillipsia, 11, 97, 98
 amarginata, 98
 bitumulata, 98
 colei, 98

- Phillipsia collinsi, 98
 cf. "Phillipsia," *sp. no.* 9, 98
 cracoensis, 99
 elongata, 98, 100
 inostranzewi, 98
 kasakensis, *var.* *aryssica* ?, 98
 kassini, 98
 kellii, 97
 kirgisica, 98
 cf. propinqua, 98
 sp., 98, 101
 sp. no. 3, 97, 100
 (*P. kasakensis var. aryssica* ?), 98
 sp. no. 9 (*cf. P. collinsi*), 98
 tulensis, 97, 98
 ? waterhousei, 98
 "Phillipsia" derbyensis, 98
 laticaudata var. kuzneciana ?, 97
 sp., 8
 Phricodothyris, 52, 53
 lineata, 53
 lucerna, 52
 periculosa, 53
 sp., 8, 10, 52
 pinguis, Brachythyris, 46
 Spirifer ex gr., *aff. integrigostia*, 47
 planus, Marginicinctus, 15
 Productus, 40
 cf. planus, Marginicinctus ?, 8, 40
 platilobus, Pugnax, 43
 plebeia, Fenestella (*Holotype*), 89
 var. longifenestra, Fenestella, 89
 aff. plebeia, Fenestella, 8, 89, 90
 cf. plebeia, Fenestella, 89
 "Plectambonites" rhomboidalis *var. analoga*, 59
 Pleurophorus *sp.*, 3
 polyporata, Fenestella, 88, 89
 Retepora, 88
 cf. polyporata, Fenestella, 8, 88
 porosus, Heliolites, 2
 Posidonia siltstones, 97
 "Poteriocrinus" *sp.*, 8, 17, 86, 91
 "princeps, Schwagerina [Pseudoschwagerina]", 11
 proboscidea, Proboscidea, 15, 39
 cf. proboscidea, Proboscidea, 38, 39
 Proboscidea, 38
 kutorgae, 41
 nana *sp. nov.*, 8, 15, 38, 39
 proboscidea, 15, 39
 cf. proboscidea, 38, 39
 sp., 15, 39
 proboscideus, Productus, 38
 Producta analoga, 58
 elegans, 60
 margaritacea, 61
 Productina, 61
 margaritacea, 8, 18, 62
 cf. margaritacea, 61
 Productus aculeatus, 27, 33
 cf. aculeatus, 33, 34
 concinus, 30
 cora, 34
 cora *var. kokdscharensis*, 35
 cora *var. tenuistriatus*, 37
 cf. cora var. kokdscharensis, 35
 deruptus, 14, 30, 31
 edelburgensis, 14, 36
 elegans, 60
 Productus giganteus, 11, 14-16, 20, 36, 43, 79
 giganteus *var. edelburgensis*, 22
 cf. giganteus, 21
 keyserlingianus, 33
 kokdscharensis, 14, 35, 36
 latissimus, 16, 32, 43
 margaritaceus, 15, 36, 61, 62
 margaritaceus *group*, 61
 cf. margaritaceus, 62
 marginicinctus, 40, 41
 nystianus, 39
 parvulus, 61
 cf. parvulus, 60
 planus, 40
 proboscideus, 38
 projectus, 41
 punctatus, 61
 punctatus *var. elegans*, 60
 pustulosus, 30
 sampsongi, 61
 scabriculus, 28, 30
 cf. scabriculus, 29
 scabriculus *var. impersonata*, 29
 var. spitiensis, 30
 ? semireticulatus, 10
 cf. semireticulatus, 31
 setiger, 41
 spinulosus, 32
 striatus, 15, 36
 aff. subelegans, 32
 tenuistriatus, 15, 37
 wortheni, 40, 41
 youngianus, 27
 var. davidsoni, 27
 yunnanensis, 34, 35
 aff. yunnanensis, 35
 Productus, Calcaires à, 30, 64, 66
 giganteus beds, 21, 22
 Limestone, Lower, 51
 Upper, 66
 Productus [Avonia] karpinskianus, 28
 multituberculatus, 32
 weberi, 28
 Productus [Krotovia] keyserlingianus, 16
 spinulosus, 11
 Productus [Waagenoconcha] humboldti, 30
 Proetus ellipticus, 99
 indosinensis, 99
 projectus, Productus, 41
 cf. propinqua, Phillipsia, 98
 Pseudouralinia zone, 12
 "Pseudomonotis" kumpani, 85
 "Pseudoschwagerina princeps, Schwagerina," 11
 Pterinopecten granosus, 83
 Pterinopectinella, 83
 granosa, 83, 84
 cf. granosa, 8, 83
 Pugnax, 41
 acuminatus, 13-15, 17, 41-43
 "acuminatus", 13, 14
 acuminatus *var. klenovi*, 42
 asiaticus *sp. nov.*, 8, 13-15, 17, 41, 42, 43
 mesogonus, 42
 platilobus, 43
 pugnus, 10, 15, 43
 cf. pugnus, 8, 10, 15, 43
 pugnus, Conchylolithus Anomites, 43

- pugnus, Pugnax, 10, 15, 43
 Rhynchonella, 43
 cf. pugnus, Pugnax, 8, 10, 15, 43
 pulcher, Punctospirifer, 63
 punctatus, Anomites, 31
 Productus, 61
 var. elegans, Productus, 60
 Punctospirifer, 18, 62, 63-65, 97
 ? billingsi, 63
 kentuckyensis, 63, 65
 ? latus, 63, 65
 malevkaensis, 63, 65
 multicostatus, 63, 65
 northi, 63
 pahangensis *sp. nov.*, 8, 11, 18, 64, 65
 partitus, 63, 65
 pulcher, 63
 aff. salemensis, Spiriferina, 65
 scabricostus, 62
 scabricostus *mut.* ashfellenensis, 18, 62, 65
 mut. redesdalensis, 18, 62, 65
 solidorostris, 63
 sp., 63
 subellipticus, 63
 subtextus, 63
 transversus, 63, 65
 verneuili, 63
 wimani, 63
 pusilla, "Cyrtosymbole", 99
 Pustula, 29
 elegans, 60
 semiglobosa, 34
 [Echinoconchus] venusta, 31
 pustulosus, Productus, 30

 quiringi, Amygdalophyllum, 9

 radialis, Hustedia, 66, 67
 Retzia, 65
 Retzia (= Hustedia), 15
 Terebratula, 65, 66
 aff. radialis, Hustedia, 66
 cf. radialis, Hustedia, 8, 18, 65, 66, 67
 redesdalensis, Punctospirifer scabricostus *mut.*, 18, 65
 remota, Hustedia, 66
 resupinata, Schizophoria, 15, 25, 26, 57
 var. baschsugensis, Schizophoria, 15
 var. dorsosinuata, Schizophoria, 25
 resupinatus, Conchylolithus Anomites, 24
 Retepora angustata, 87
 polyporata, 88
 Reticularia, 53
 acutiloba, 55
 alexandri, 54
 cf. alexandri, 8, 10, 15, 16, 54, 55
 beschewiana, 16, 55
 elliptica, 15, 55
 imbricata, 8, 10, 13, 53, 54
 lineata, 10, 53
 lobata, 55
 cf. retiformis, Fenestella, 3
 Retzia radialis, 65
 Retzia [= Hustedia] radialis, 15
 Rhacopteris, 79
 ovata, 79
 Rhodea *sp.*, Sphenopteris, 79

 rhomboidalis, Conchita, 58
 var. analoga, Leptaena, 59
 var. analoga, Plectambonites, 59
 var. analoga, Strophomena, 58
 rhomboidea, Camerophoria, 27
 Stenosisma [= Camerophoria], 27
 var. arctica, Camerophoria, 27
 Rhynchonella acuminata, 43
 pugnus, 43
 "Rhynchonella" acuminata, 43
 rhynchonellid, 3
 roissii, Cleiothyridina, 55
 royssii, Athyris, 55
 rudis, Fenestella, 89
 rugosus, Caragandites, 78

 "Saccamina" carteri beds, 31
 saguensis *sp. nov.*, Stenosisma, 8, 10, 26, 27
 salemensis, Spiriferina, 18, 65
 (= Punctospirifer), 65
 aff. salemensis, Spiriferina, 63
 sampsoni, Productus, 61
 scabricostus, Punctospirifer, 62
 mut. ashfellenensis, Punctospirifer, 18, 62, 65
 mut. redesdalensis, Punctospirifer, 18, 62, 65
 scabricula, Buxtonia, 16, 29
 scabriculus, Productus, 28, 30
 cf. scabriculus, Productus, 29
 scabriculus var. impersonata, Productus, 29
 var. spitiensis, Productus, 30
 Schizodus *sp.*, 3
 Schizophoria, 18, 24, 25, 57
 connivens, 25
 gibbera, 25
 hudsoni, 25
 mesoloba, 8, 10, 15, 16, 24, 25, 57
 nuda, 25
 palliat, 25
 resupinata, 15, 25, 26, 52
 resupinata var. baschsugensis, 15
 var. dorsosinuata, 25
 sp., 8, 17, 25, 57, 58
 woodi, 25
 schlotheimi, Terebratulites, 26
 Schwagerina, 11
 Schwagerina beds, 38
 Limestone, 41
 zone, 27
 "Schwagerina [Pseudoschwagerina] princeps", 11
 scrivenori *sp. nov.*, Spirifer, 8, 10, 15, 16, 50, 51, 52
 scrobiculatus, Astero calamites, 79
 semibugensis, Leptaena, 59
 semicircularis, Spirifer, 47
 semiglobosa, Pustula, 34
 Seminula zone, 12, 14, 18, 35, 62
 Seminula zone, Lower, 93
 semireticulatus, Anomites, 30
 ? semireticulatus, Productus, 10
 cf. semireticulatus, Productus, 31
 setiger, Productus, 41
 Setigerella [= Setigerites], 41
 Setigerella [= Setigerites] setiger, 41
 Setigerites, 41
 [= Setigerella], 41
 sibiricus, Spirifer, 14, 48, 49
 sinuata, Leptaena, 18, 39, 58
 Sinuatella, 16, 40

- Sinuatella, 39, 40
 beushauseni, 40
 gaablauensis, 40
 orientalis *sp. nov.*, 8, 10, 39, 40
 sinuata, 16, 40
 subsinnuata, 40
 Siphonophyllia cylindrica, 93
 Solemya, 83
 ? Solemya *sp.*, 8, 53
 Solenocheilus, 4, 6
 Solenomya, 83
 solidorostris, Punctospirifer, 63
sp. no. 3 (P. kasakensis *var. aryssica*?) Phillipsia, 97
sp. no. 9 (cf. P. collinsi) "Phillipsia", 98
 Sphenophyllum, 79
 Sphenopteridium ? furcillatum, 79
 Sphenopteris (Rhodea) *sp.*, 79
 spinulosa, Krotovia, 15, 33
 spinulosus, Productus, 32
 spinulosus, Productus [Krotovia], 11
 Spirifer, 44, 49
 bisulcatus, 14-16, 36, 45-47
 bisulcatus ?, 14
 "bisulcatus", 36
 bollandensis, 51
 carinatus, 51
 condor, 17, 49, 50
 cf. condor, 8, 15, 17, 49, 50, 52
 derjawni, 14, 15, 48, 49
 deroissii, 55
 duplicosta, 50
 duplicicostus, 10, 15, 51
 fasciger, 48
 humerosus, 47, 48
 aff. integricostus, 16, 47
 liangchowensis, 12, 52
 logani, 16, 51
 lutugini, 16, 51, 52
 marcoui, 51, 52
 mortonanus, 51
 cf. mosquensis, 10
 ovalis, 44
 ex. gr. pinguis aff. integricosta, 47
 scrivenori *sp. nov.*, 8, 10, 15, 16, 50, 51, 52
 semicircularis, 47
 sibiricus, 14, 48, 49
 sp., 8, 12, 45
 sp. (striatus group), 52
 striatus, 16, 51
 striatus group, 8
 subconicus, 99
 urii, 59
 Spirifer tonkinensis horizon, 99
 Spirifer (Anelasma) variants, 47
 [? Chorisites] humerosus, 13
 Spirifera humerosa, 47
 Spiriferellina, 63, 65
 Spiriferid, smooth, 8
 Spiriferina, 62
 cambodgiensis, 64
 cristata, 65
 laminosa, 18
 molleri, 63
 partita, 65
 peracuta, 63
 salemensis, 18
 aff. salemensis, 63
 sp., 63
 Spiriferina transversa, 18
 Spiriferina ?, 10
 "Spiriferina" laminosa, 63
 Spiriferina [=Punctospirifer] *aff. salemensis*, 65
 spitiensis, Productus scabriculus *var.*, 30
 Squamularia, 53
 Stenopora *sp.*, 3
 Stenosisma, 26
 saguensis *sp. nov.*, 8, 10, 26, 27
 [Camerophoria] rhomboidea, 27
 Stigmara, 78
 sp., 8
 Streblochondria, 84
 ? Streblochondria *sp.*, 8, 84
 Streblopteria, 84, 85
 hemispherica, 85
 laevigata, 85
 sp., 8, 84
 striatus, Productus, 15, 36
 Spirifer, 16, 50
 striatus group, Spirifer *sp.*, 12, 52
 Strophomena rhomboidalis *var. analoga*, 58
 sp., 4
 subconicus, Spirifer, 99
aff. subelegans, Productus, 32
 subellipticus, Punctospirifer, 63
 suborbicularis *mut. kokuensis*, Brachythyris, 44, 45
 subrotundata, Brachythyris, 45, 46
 subsinuata, Sinuatella, 40
 subtextus, Punctospirifer, 63
 Syringothyris, 51
 Syringothyris Limestone, 13, 29
 Syringothyris zone, 93, 94

 taffiana, Anthraconeilo, 90, 91
aff. taffiana, Anthraconeilo, 8, 90
 tenax, Fenestella, 88
aff. tenax, Fenestella, 88
cf. tenax, Fenestella, 8, 88
cf. tenuis, Leptodus [Lyttonia], 5
 tenuistriatus, Linoproductus, 8, 11, 12, 15, 37, 38
 Productus, 15, 17, 37
 Productus cora *var.*, 37
 "tenuistriatus", Linoproductus, 14, 15, 17
 terapaiensis *sp. nov.*, Linguaphillipsia, 8, 97, 99, 100, 101
 Terebratula imbricata, 53
 mormoni, 65
 radialis, 65, 66
 Terebratulites elongatus, 56
 schlotheimi, 26
 Thomasella, 61
 Thomasia, 61
 Thomasina, 61
 cf. margaritaceus, 62
 thomsoni, Amygdalophyllum, 9
 Thysanophyllum zone, 12
 timorensis, Uncinunellina, 5
 tonkinensis horizon, Spirifer, 99
 transversus, Punctospirifer, 63, 65
 Spiriferina, 18
 tulensis, Linguaphillipsia, 98
 Phillipsia, 97, 98
 Tylothyris, 63
 cf. laminosa, 11
 Typhloproetus, 99
 "Tyrgania", 79

Uncinunellina timorensis, 5
urii, Spirifer, 59

varians, Spirifer (Anelasma), 47
aff. varians, Brachythyris, 47
variolata, Chonetes, 59
venusta, Pustula [= Echinoconchus], 31
verneuili, Punctospirifer, 63
verneuilliana, Camerophoria, 27
Viviparus, 5, 108

Waagenoconcha humboldti, Productus, 30
wallichi, Halysites, 2
wangi, Amygdalophyllum, 9
Waribole, Cyrtosymbole, 99
waterhousei, Phillipsia ?, 98
weberi, Avonia, 8, 10, 15, 28
Productus (Avonia), 28
wettonensis, Dictyoclostus hindi var., 31

INDEX

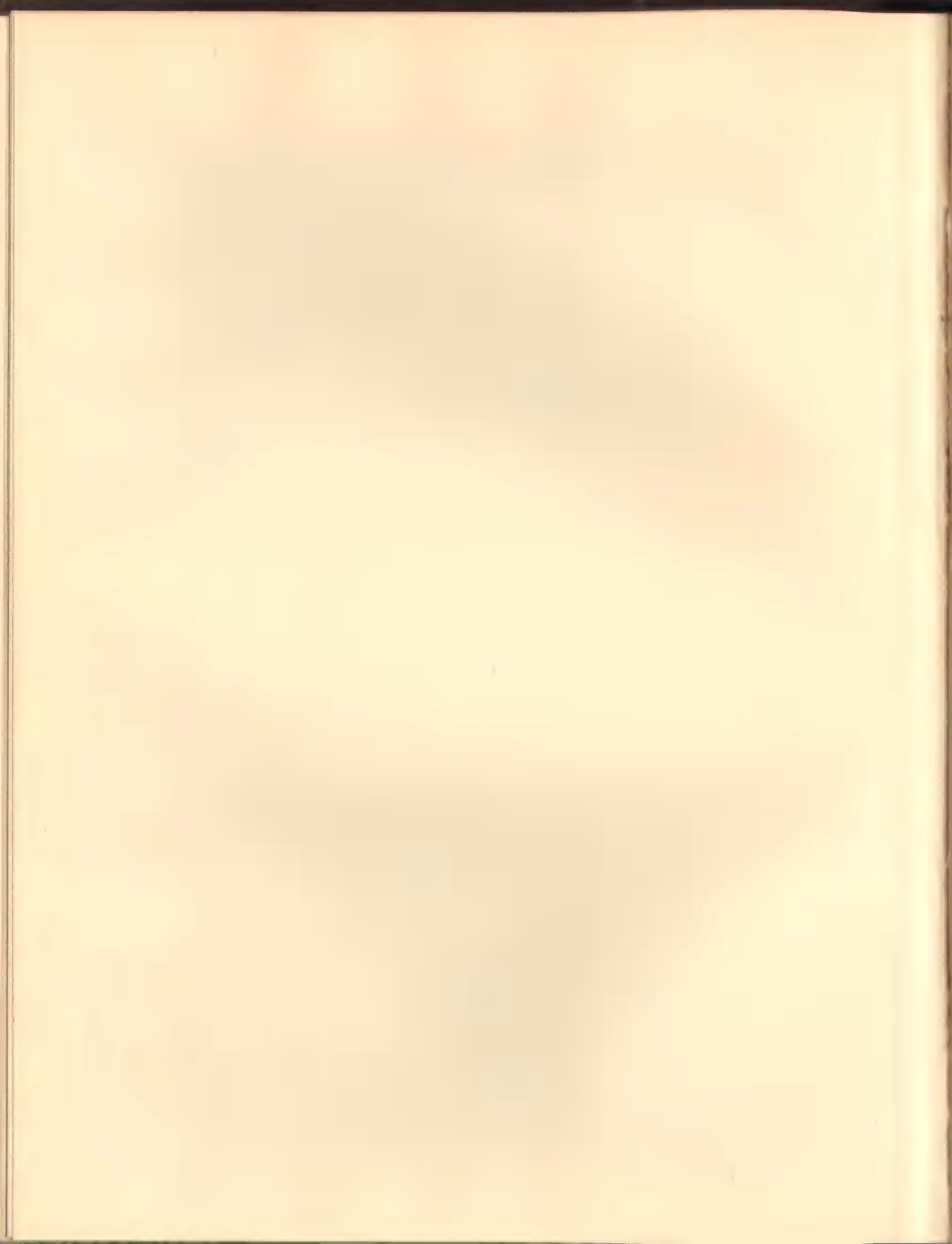
willbourni sp. nov., Brachythyris, 8-10, 14-16, 45
46, 48
wimani, Punctospirifer, 63
woodi, Schizophoria, 25
Worthenella, 40
wortheni, Productus, 40, 41

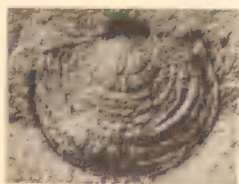
Xenodiscus, 4, 108

Yoldia, 91
youngianus var. davidsoni, Productus, 27
Yuanophyllum zone, 12, 13, 15, 21, 22
yunnanensis, Linoproductus, 8, 12, 17, 34, 35, 36
Productus, 34, 35
aff. yunnanensis, Productus, 35

Zaphrentis, 10
Zaphrentis zone (= Cystophrentis zone), 12

PLATES

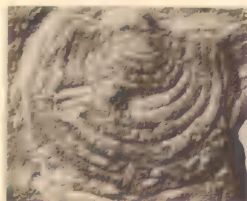




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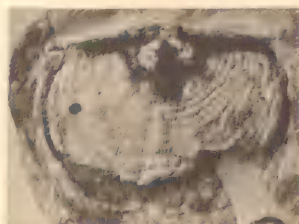
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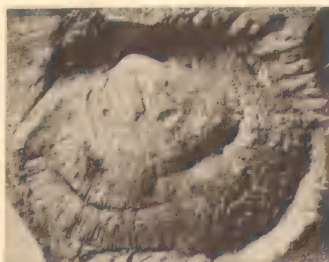
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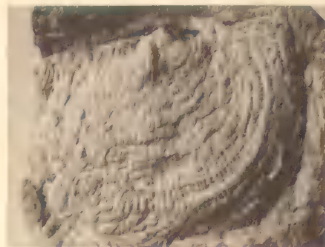
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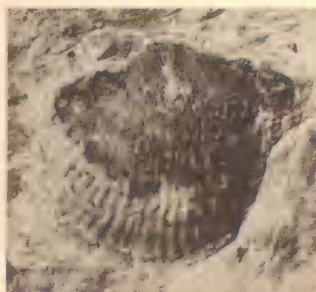
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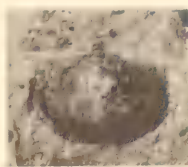
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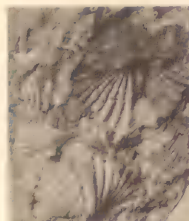
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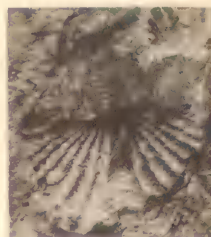
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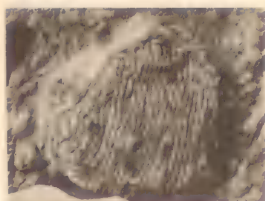
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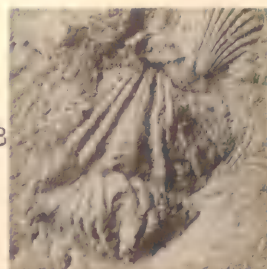
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A

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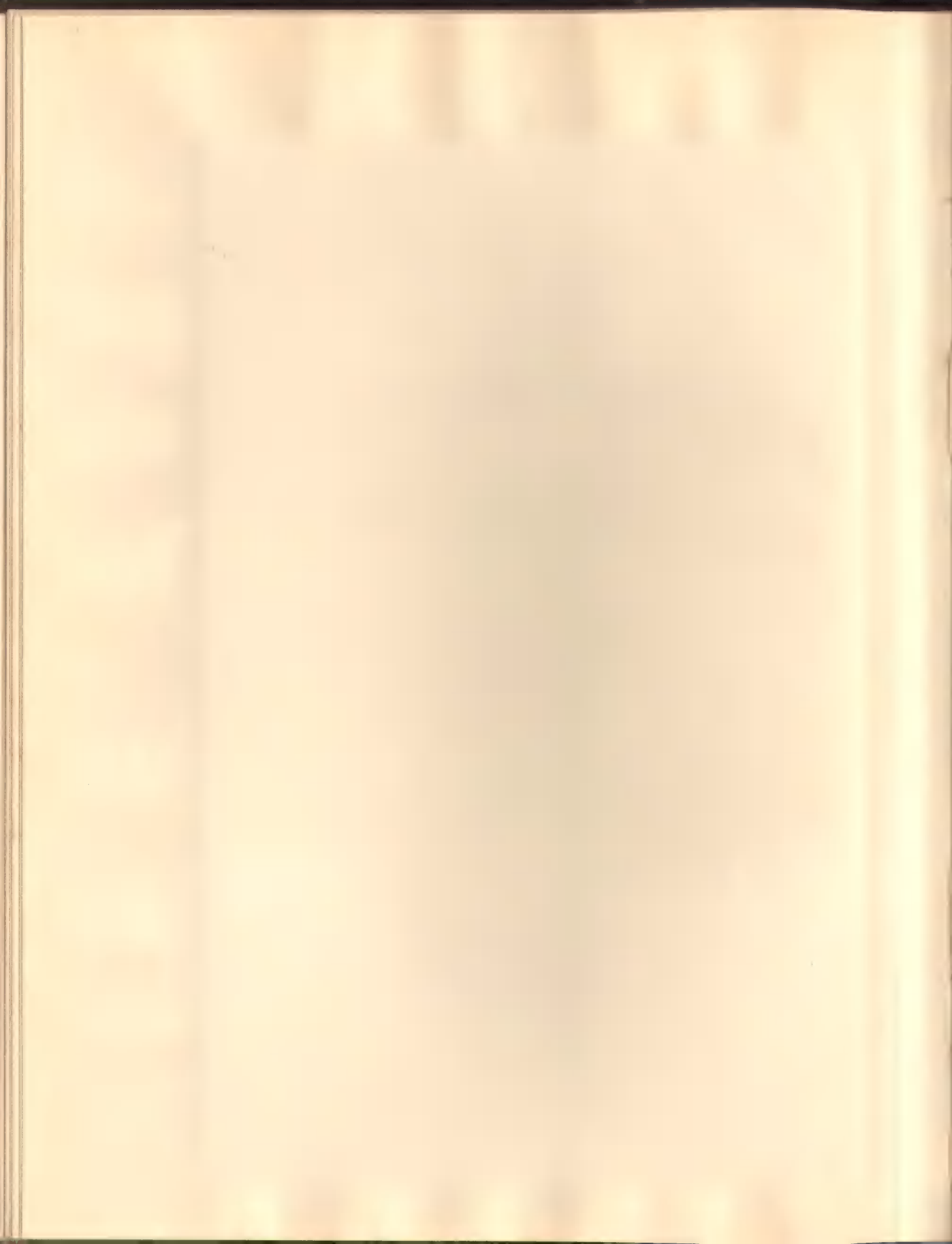




LOWER CARBONIFEROUS BRACHIOPODS FROM MALAYA.



LOWER CARBONIFEROUS BRACHIOPODS FROM MALAYA.





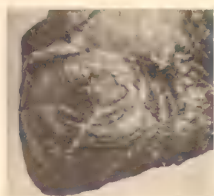
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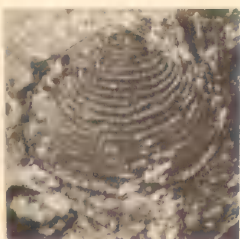
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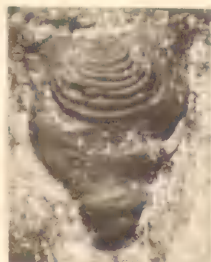
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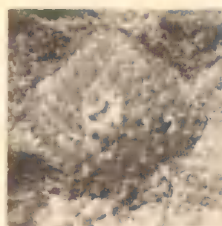
5



6



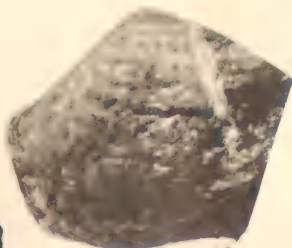
7



8



9



12



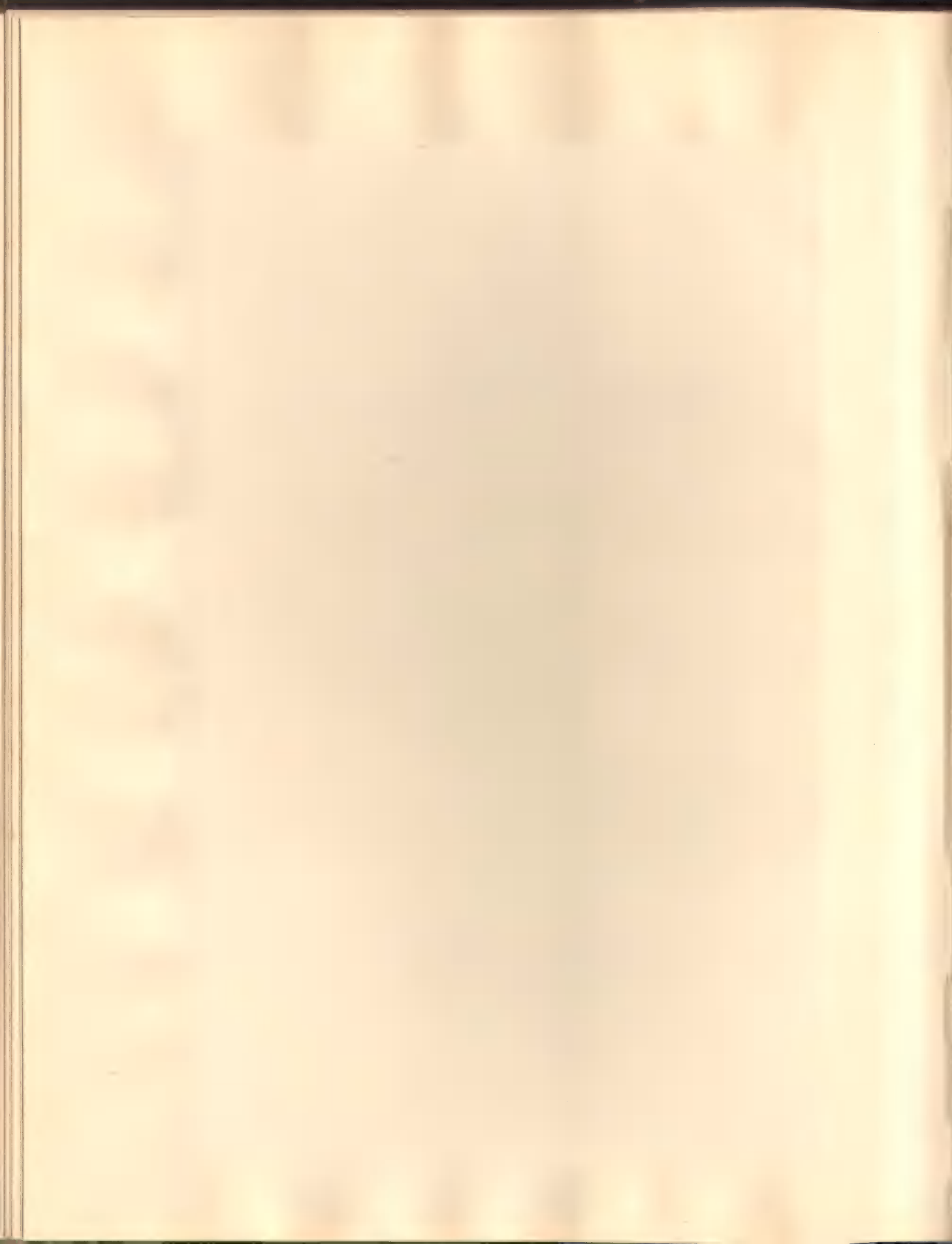
10



11a



11b





1a



2a



2b



3a



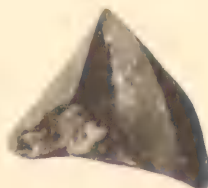
3b



3c



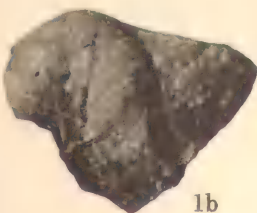
4a



4b



4c



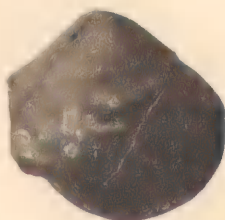
1b



1c



1d



5a



5b



6



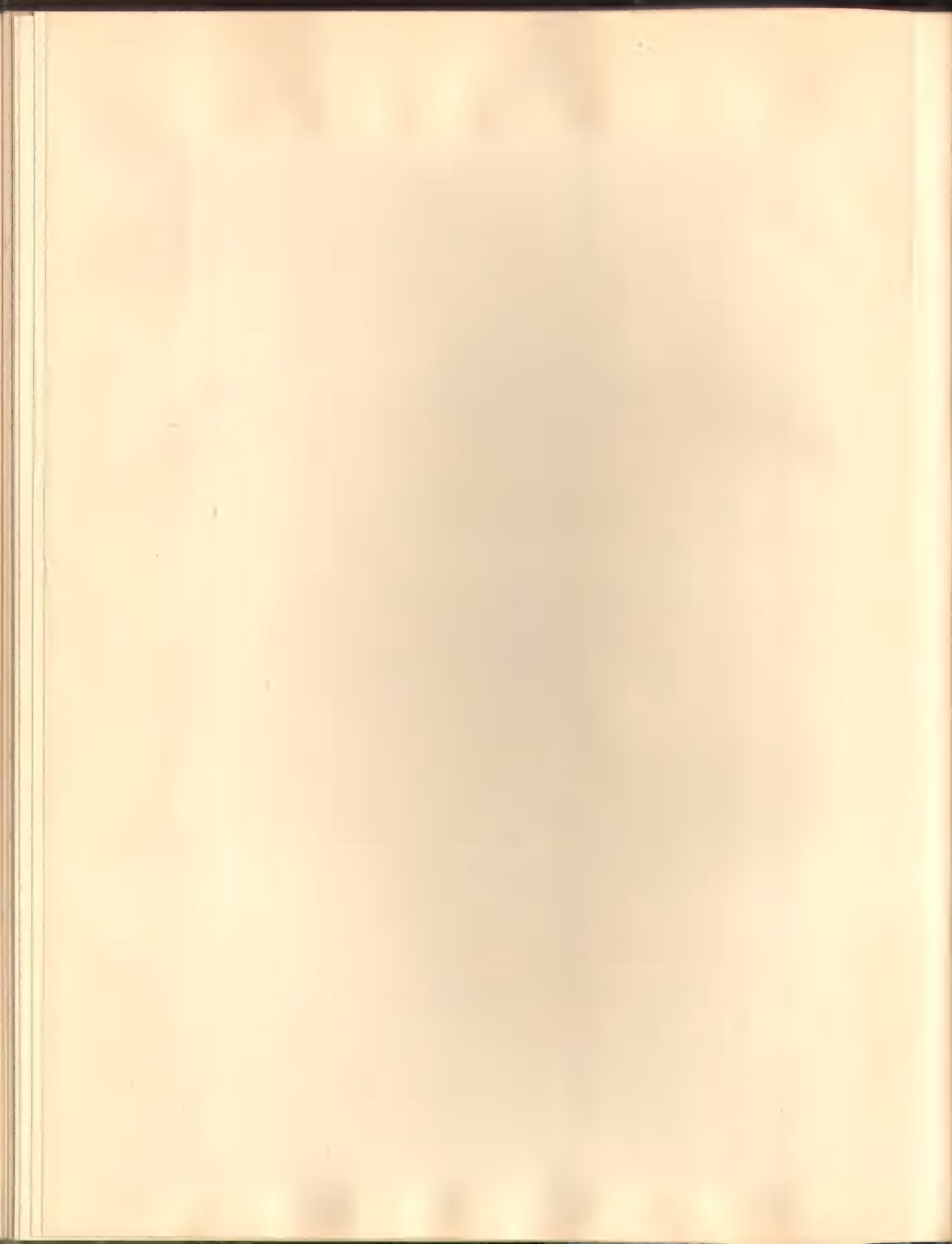
LOWER CARBONIFEROUS BRACHIOPODS FROM MALAYA.



LOWER CARBONIFEROUS BRACHIOPODS FROM MALAYA.



LOWER CARBONIFEROUS BRACHIOPODS FROM MALAYA.





1



2

× 2



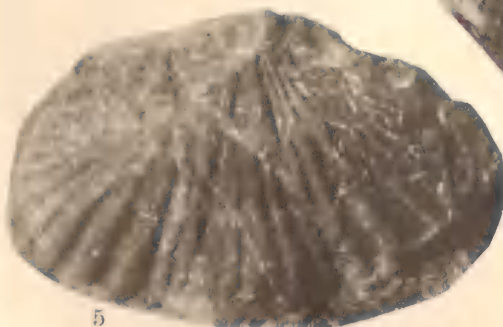
3



4



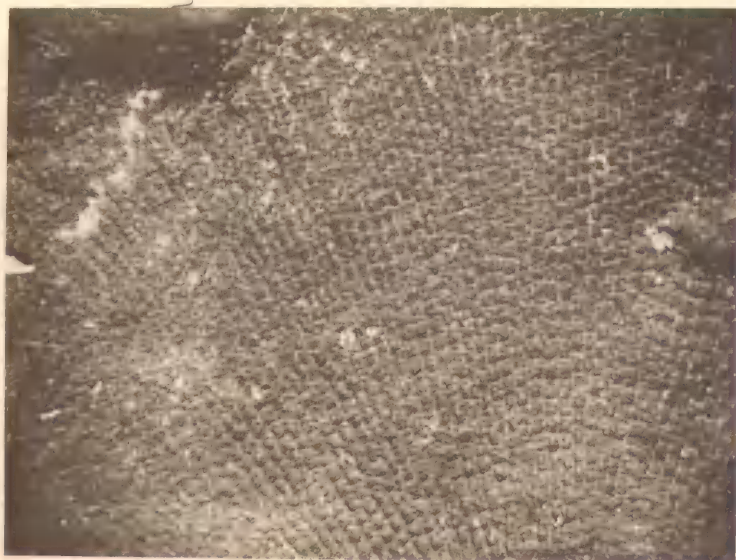
6



5

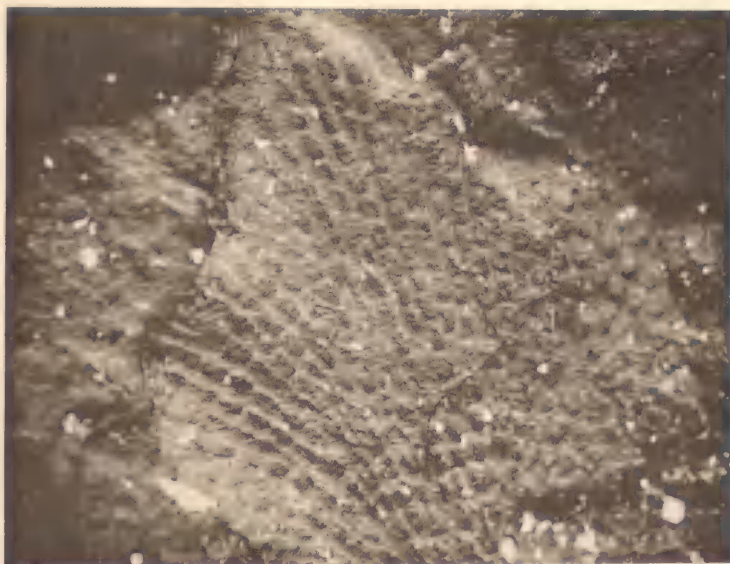
LOWER CARBONIFEROUS PLANTS AND BRACHIOPODS FROM MALAYA.





1

× 5

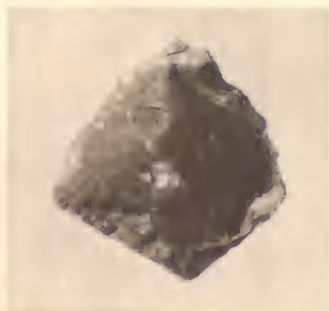


2

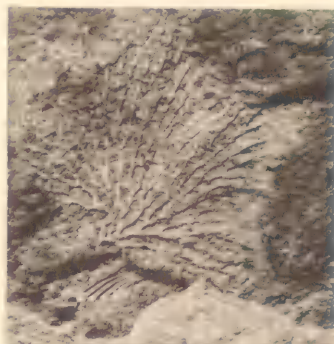
× 5

LOWER CARBONIFEROUS BRYOZOA FROM MALAYA.





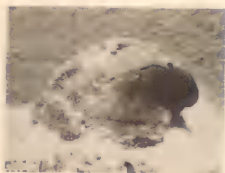
4 $\times 1$



1 $\times 2$



2 $\times 1$



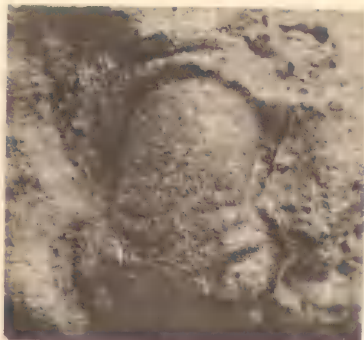
6 $\times 2$



5 $\times 1$

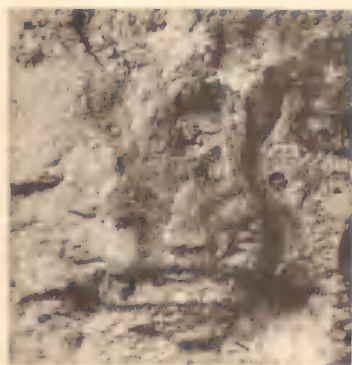


3 $\times 1$



1

x 4



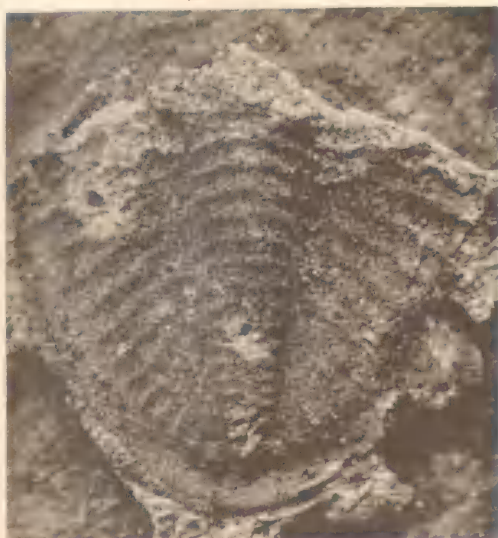
2

x 4



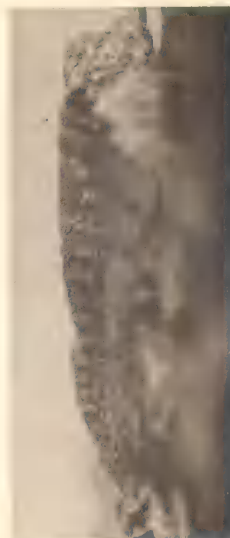
3

x 4



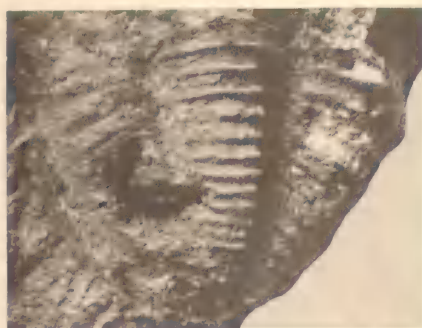
1a

× 4



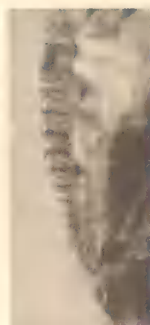
1b

× 4



2a

× 4



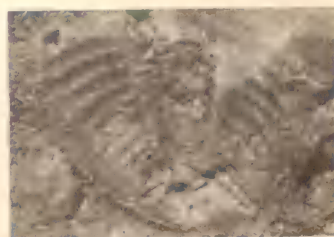
2b

× 4



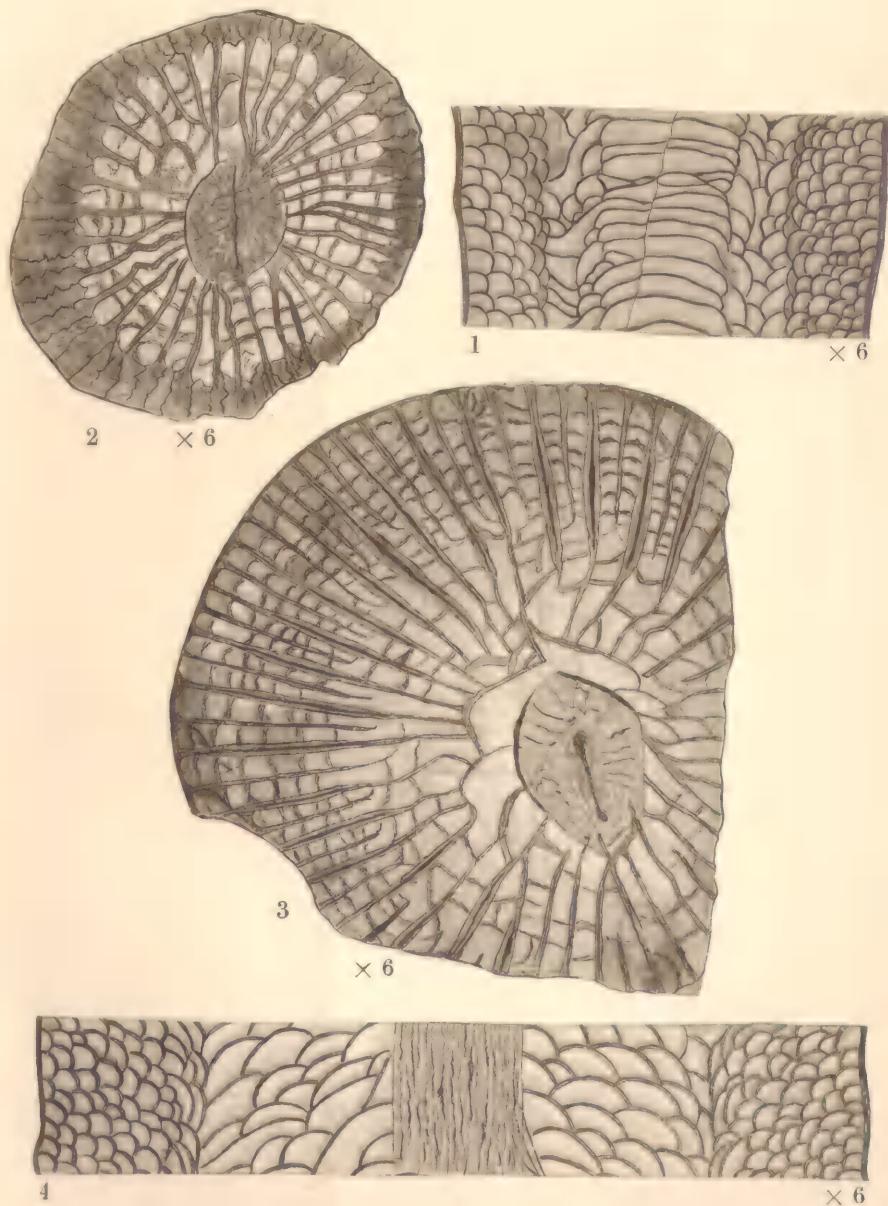
2c

× 4



3

× 4



LOWER CARBONIFEROUS CORALS FROM MALAYA.





MAP OF MALAYA SHOWING FOSSIL LOCALITIES (see pp. 2 and 107).

WISEAN LAND & SEA

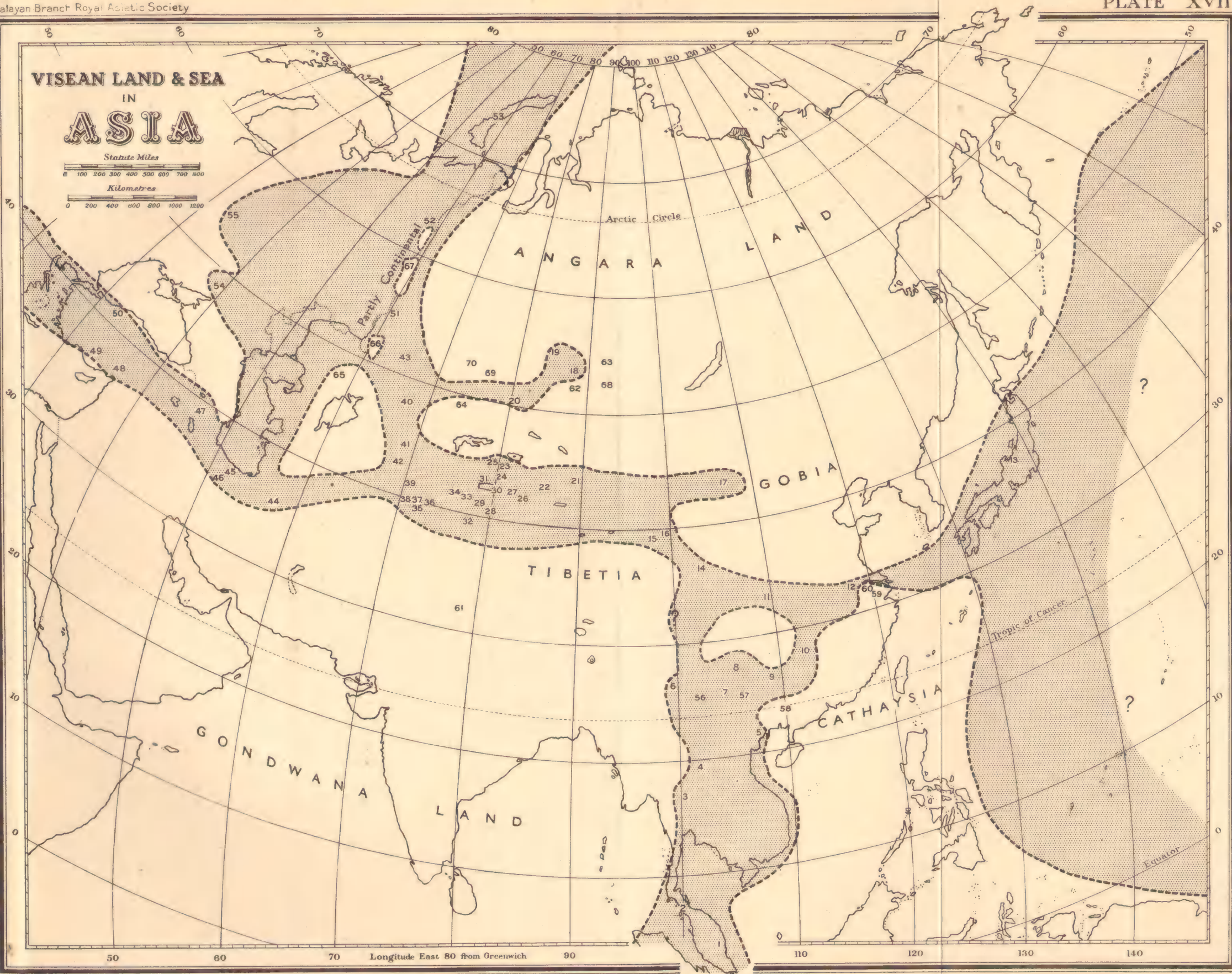
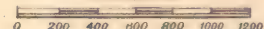
IN

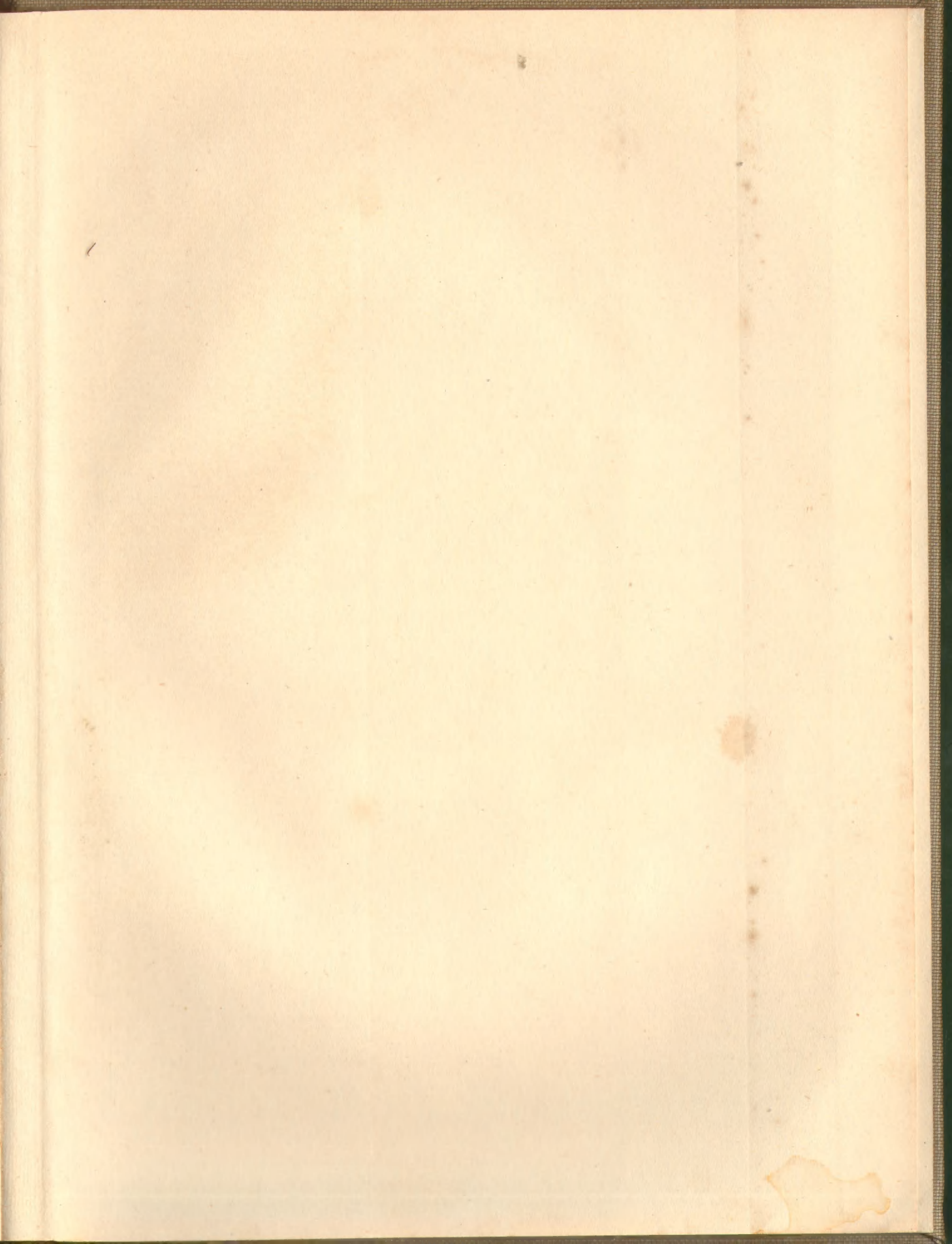
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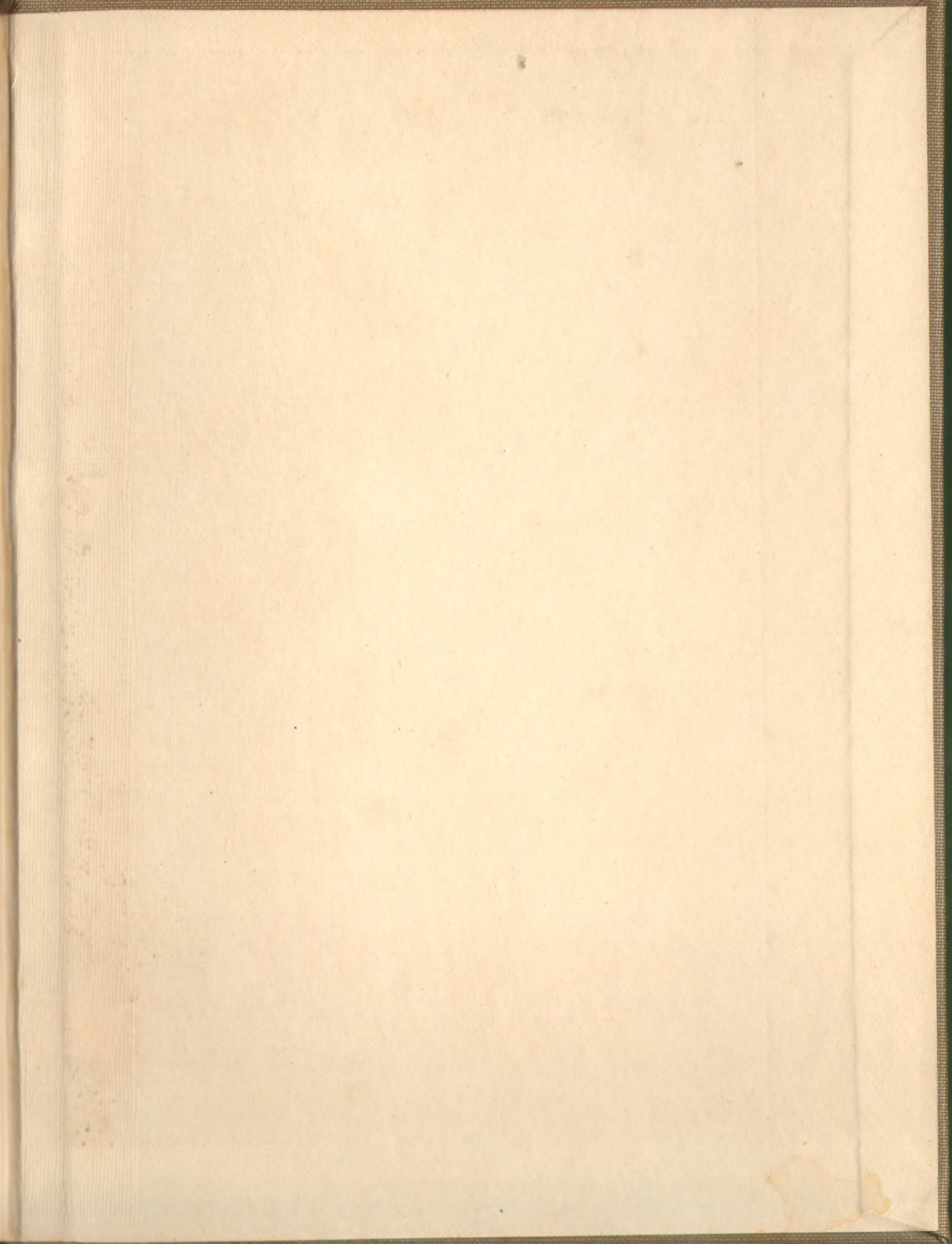
Statute Miles



Kilometres







MALAYAN
LOWER
CARBON-
IFEROUS
FOSSILS

MUIR-WOOD

HEIR MUSE
NAT. HIST.
1913